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Coal Quality, Coal Rank Variation and its Relation to Reconstructed Overburden, Upper Cretaceous and Tertiary Plains Coals, Alberta, Canada

by

© John R. Nurkowski

A THESIS

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ABSTRACT

Near-surface coals in the Alberta plains occur in Upper Cretaceous and Tertiary sediments, the former represented by the Belly River Group, Horseshoe Canyon Formation and Wapiti Formation, and the latter by the Scollard Member of the Paskapoo Formation. These coal-bearing units contain significant coal resources of varying quality and rank. Statistical techniques were used to document both the distribution of, and the interrelationships between, the components of proximate and ultimate analysis and calorific value determinations.

The coals discussed range in rank from subbituminous C to high volatile bituminous C. These coals have variable ash content and low sulfur content. The relationships between calorific value (dry basis, kJ/kg) and ash (dry basis, %), and calorific value (moist mineral matter free, kJ/kg) and equilibrium moisture (MEQ, %) were determined to be

CV(D) = 29262 - 286(Ash[D]) (±1642 kJ/kg)

and CV(MMMF) = 31816 - 442(MEQ) (±1408 kJ/kg),

respectively.

A model for coal rank distribution in the Alberta plains, proposed in this study, took into consideration the maximum (paleo-) depth of coal seam burial. This maximum depth (DOB, m) was reconstructed on the basis of previously published graphs, relating the equilibrium moisture loss to depth of coal seam burial, using the relationship

log[10]MEQ = 1.865 - 0.000416(DOB).

A least squares regression analysis of calorific value (MMMF, kJ/kg) on the calculated depth of burial (DOB, m) yielded the equation

$$CV(MMMF) = 14748 + 6.25(DOB),$$

indicating a coalification gradient, determined on the reconstructed overburden, of 6.25 kJ/kg per metre (0.82 Btu/lb/ft) of depth (or overburden).

Near-surface coals in the Alberta plains increase in rank toward the west southwest (toward the foothills / mountains region) because of progressively greater amounts of overburden that existed in that direction during Tertiary time. Erosion has since removed between 900 and 1900 m (2953 and 6234 ft) of sediment, with the greatest amount of removal occurring in a west southwest direction.

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I. INTRODUCTION

A. BACKGROUND

In the course of its on-going investigation of the coal resources in the Alberta plains, the Geological Survey Department of the Alberta Research Council has accumulated a large number of proximate and ultimate analyses of coal samples. Between 1974 and 1980, 685 coal samples were analyzed and the results of these analyses were made available to the author for a research project (Appendix 1). The purpose of the project was two-fold. The first was to describe and summarize the distribution of each of the components of a proximate and ultimate analysis for each coal-bearing unit, using the recently acquired data. The last comprehensive attempt at this was by Campbell (1964), using data accumulated by the Alberta Research Council between 1944 and 1963. In addition to describing the distributions of individual components, component interrelationships were also to be investigated. The second purpose of the research project was to use the bed moisture content of the coal, which had previously been identified as possibly controlled by original depth of coal seam burial (Hacquebard, 1977), to reconstruct the maximum paleotopographic surface in the central plains area of Alberta. This surface can then be looked at as a possible controlling factor in determining the present day distribution of coal ranks. Coal geologists working in the

plains area of Alberta have generally not excepted this hypothesis, with these geologists tending to relate the coal rank variations observed in the plains area to forces accompanying the uplift of the Cordillera (Campbell, 1983; Campbell, 1972; Stansfield and Lang, 1944)

B. REGIONAL GEOLOGY AND SAMPLE DISTRIBUTION

The coal-bearing portion of Alberta can be divided into two geographic regions, the folded and faulted foothills and mountain region, and the flat-lying to gently dipping plains region (Fig. 1). Coals of significant thicknesses are known to occur in both areas in Lower Cretaceous, Upper Cretaceous and Tertiary rocks (Williams and Murphy, 1981; Yurko, 1975; Stansfield and Lang, 1944).

Four prolific coal-bearing horizons are present within Upper Cretaceous and Tertiary sediments in the plains of Alberta: Foremost and Oldman Formations of the Belly River Group, Horseshoe Canyon Formation, Wapiti Formation, and Scollard Member of the Paskapoo Formation (Fig. 2). The outcrop extent of each of these units is shown in Figure 1. Except in areas of present-day active erosion (for example, the banks of major rivers), the entire plains area is covered by a thin layer of glacially-deposited Quaternary sediment. The coal-bearing strata dip regionally to the west southwest (ERCB, 1982), from near horizontal in the eastern portion of the plains area to over 8.6 m per km in areas near the foothills (Williams and Burk, 1964).

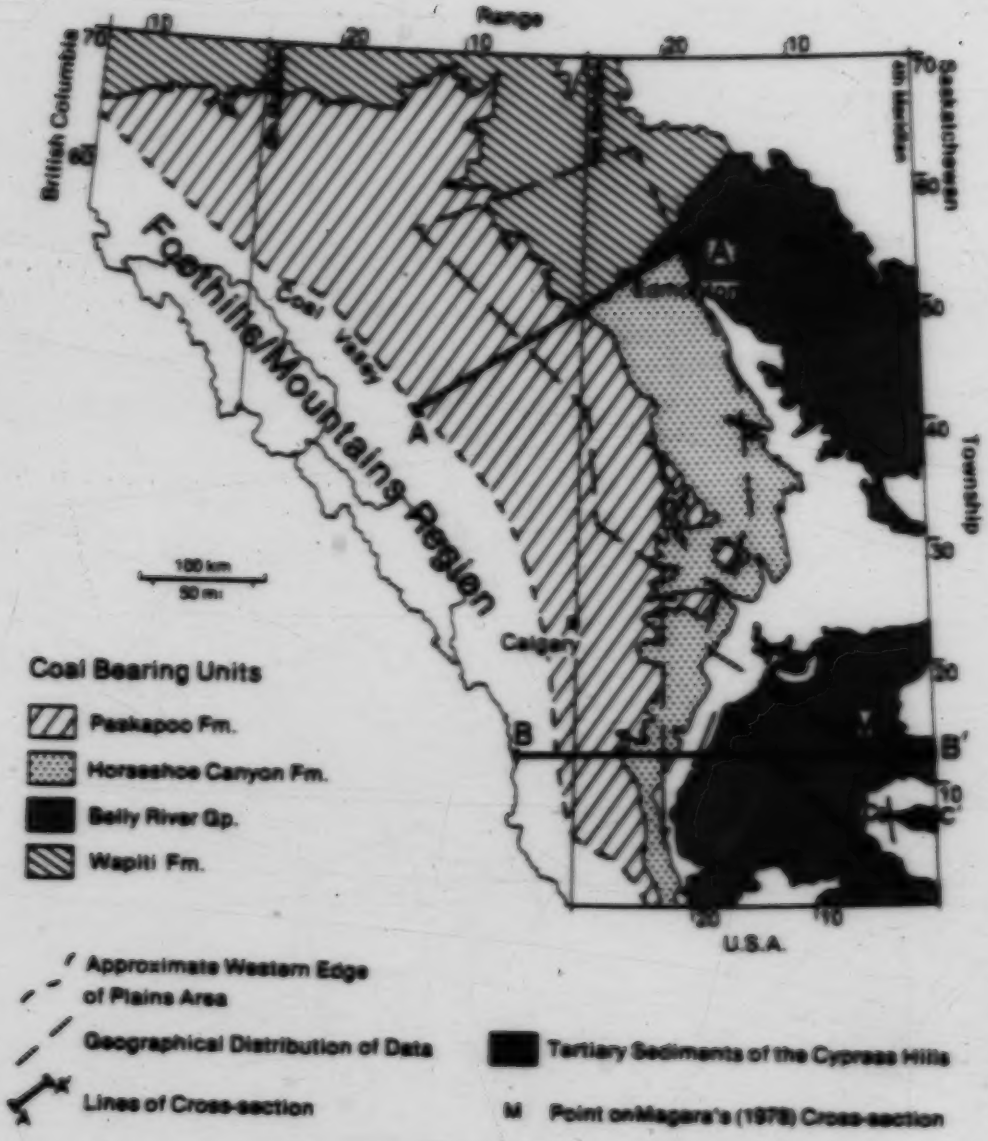

Figure 1: Outcrop distribution of Upper Cretaceous and Tertiary coal-bearing units (from the Geological map of Alberta).

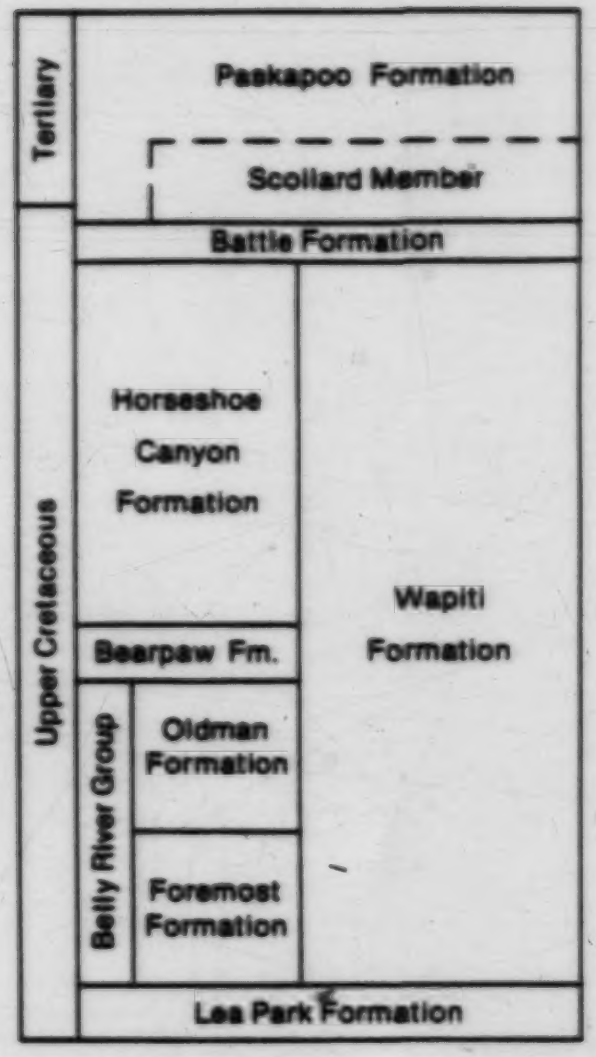

Figure 2: Upper Cretaceous and Tertiary stratigraphic nomenclature of the central plains area. The stratigraphic units noted were compiled following William and Burk (1964), Irish (1970) and Nurkowski and Rahmani (in press).

The Belly River Group', subdivided locally into the Foremost and Oldman Formations, and the Wapiti Formation are used as defined in Williams and Burk (1964), and the Scollard Member of the Paskapoo Formation is used as defined in Irish (1970). In this study the Horseshoe Canyon Formation encompasses the Horseshoe Canyon Formation as well as the Whitemud Formation of Gibson (1977) and Irish (1970). Use of this new definition of the Horseshoe Canyon Formation can be found in Nurkowski (1980) and Nurkowski and Rahmani (in press).

The Belly River Group (Fig. 2), lowermost of the outcropping coal-bearing units, is sandstone dominated, containing coals, siltstones and shales. Individual coal seams attain thicknesses up to 3 m (10 ft), with cumulative coal thicknesses up to 6 m (20 ft; Holter *et al.*, 1978). Deposition of the sediments occurred in continental, marine and marginal marine environments (Williams and Burk, 1964).

The Bearpaw Formation (Fig. 2) is shale-dominated and contains minor amounts of sandstone. Thin coal seams of considerable lateral continuity have been found in the upper part of this formation, but whether or not they belong stratigraphically and genetically to the overlying Horseshoe Canyon Formation is questionable. The Bearpaw Formation was deposited under marine and marginal marine conditions (Williams and Burk, 1964).

'also known as the Judith River Formation

The Horseshoe Canyon Formation (Fig. 2) is sandstone dominated, with coals, siltstones and shales. Coal seams up to 5 m (16 ft) thick and areas with cumulative coal thicknesses up to 12 m (39 ft) occur within this formation (Holter *et al.*, 1976). Sediment deposition is considered to have occurred in both continental and marginal marine environments (Rahmani, 1981; Nurkowski and Rahmani, in press.).

The Wapiti Formation (Fig. 2) occurs in the north-central portion of the province (Fig. 1) and is defined as containing sediments of the Belly River Group and the Horseshoe Canyon Formation in areas where the Bearpaw Formation is absent. The Wapiti Formation is sandstone dominated, containing coals, siltstones and shales. Coal seams up to 3 m (10 ft) thick have been encountered within this formation (Chu, 1978).

The Battle Formation (Fig. 2) is a wide spread unit deposited in a swampy to lacustrine environment (Binda, 1970) and is devoid of coal. This formation is very useful for separating the lithologically similar upper Horseshoe Canyon Formation from the lower Paskapoo Formation. It is readily recognizable in outcrop by its medium to dark purplish-grey to lime-grey color (Gibson, 1977) and, in subsurface geophysical logs, by its very low resistivity and higher gamma ray readings. Due to its thinness (commonly 7 to 11 m [22 to 36 ft]; Nurkowski and Rahmani, in press), the formation was not plotted in the outcrop map (Fig. 1).

The Scollard Member of the Paskapoo Formation (Fig. 2) is the uppermost of the major coal-bearing units and contains both the thickest and the most continuous coal seams. It is defined as the generally finer-grained section of sediments overlying the Battle Formation and containing the thick coals traditionally named the "Ardley" coals. Coal occurrences in Paskapoo Formation sediments other than in the Scollard Member are rare. Coal seams up to 5 m (16 ft) thick, as well as coal zones with cumulative coal thicknesses up to 24 m (79 ft) occur in this member (Nurkowski, in prep.). Paskapoo Formation sediments and coals are considered to have been deposited within a continental environment (Carrigy, 1971).

Between 1974 and 1980 the Alberta Research Council drilled 427 testholes into the above-mentioned coal-bearing units in order to evaluate plains area coal resources. These testholes are concentrated in areas where the coal-bearing units are shallow, near their outcropping edge (Fig. 1). In total, these drilling programs accumulated information on 89.6 km (293,963 ft) of drilled sediment and 2.1 km (6,890 ft) of cored sediment. Coal samples were taken periodically when coal seams were encountered during conventional open hole drilling. These samples were washed, bagged and sent for analysis. Portions of coal seams collected from cores were also bagged and sent for analysis. Contamination of coal samples (especially cuttings) by up-hole coal seams was not considered a major problem.

Inspection of caliper tracks on geophysical logs indicate that shallow coals (less than 500 m) tend not to cave or wash out, and that this property of coal seams would minimize contamination.

In total, 685 proximate analyses, 621 calorific value determinations and 104 ultimate analyses were performed (Appendix 1).

C. PREVIOUS WORK

The first detailed account describing the composition and quality distribution of coals in Alberta was by Stansfield and Lang (1944), who used mine samples for analyses. Their study found that coal quality (increase in calorific value, decrease in moisture content) increased toward the mountain front. This increase was attributed to "mountain building pressures" and, to a lesser extent, to geologic age and present depth of the coal seam (Stansfield and Lang, 1944, p. 9).

Campbell (1964) summarized coal composition and quality data for coal mines that had been, or were, operating in the plains area of Alberta. Campbell (1972) used coal samples from oil and gas wells to determine a vertical coalification gradient, which was found to be 5.34 kJ/kg (moist ash-free) per metre of depth (0.7 BTU/lb/ft). In explaining the increase in coal rank in a direction toward the mountain front, Campbell (1983) supported the views of Stansfield and Lang (1944) by stating (p. 2) "... the uplifting of the

Cordillera ... was accomplished by a continous horizontal force ... that could metamorphose the coal just as effectively as overburden weight."

Steiner *et al.* (1972), in part using data from Campbell (1964), also discussed composition and quality variation of coals from the plains area of Alberta. As in Stansfield and Lang (1944), moisture content was found to decrease, and calorific value to increase, towards the foothills and mountain region. This study also noted that ash content increased to the southwest, an effect that was attributed to contamination from wind-blown volcanic ash from the southern Cordillera.

Previous work on coal metamorphism, or coalification, has been well summarized by, among others, Bustin *et al.* (1983), Berkowitz (1979) and Teichmüller and Teichmüller (1968), and this study relied heavily on these references. Coalification results from the interaction of three controlling parameters: temperature, pressure and time. Increasing temperature is considered to be responsible for chemical changes associated with increasing rank (Berkowitz, 1979; Teichmüller and Teichmüller, 1968) and increasing pressure is associated with physical-structural changes (Teichmüller and Teichmüller, 1968) that accompany increasing rank. The third parameter, time, affects coalification in that a higher degree of coalification can be achieved during a shorter period of time if the coal was subjected to a higher than usual temperature. Relationships

between time and temperature have been developed by Karweil (1956) and are discussed in more detail in Hacquebard (1977) and Berkowitz (1979). These relationships were applied exensively in Hacquebard's (1977) study of the coalification history of Mannville coals. Here, Hacquebard used bed moisture contents of near-surface coals from Steiner *et al.* (1972) and the vitrinite reflectance of Mannville Formation coals (Lower Cretaceous) to estimate maximum burial depths and paleotemperatures for Mannville Formation sediments. Because vitrinite reflectances, which are indicators of thermal maturation (Teichmüller and Teichmüller, 1968), were not available, application of Karweil's (1956) model to determine the thermal history of the coals discussed in this study was not possible. In order to obtain a rough estimate of the temperature required to mature the coals discussed in this study, the maximum vitrinite reflectance expected was estimated from a relationship of vitrinite reflectance versus carbon content from Berkowitz (1979). This value of vitrinite reflectance could then be compared to a table of minimum paleotemperatures required to mature coals to a particular reflectance value (Bostick, 1979).

Coal seam nomenclature, depositional settings, and description of overlying and underlying lithology for coal-bearing horizons can be found in Rahmani (1981) for the lower Horseshoe Canyon Formation, Nurkowski (1980) and Nurkowski and Rahmani (in press) for the upper Horseshoe Canyon Formation, Chu (1978) for the Wapiti Formation,

Holter *et al.* (1978) for the Belly River Group, Gibson (1977) for the Horseshoe Canyon Formation and the Scollard Member, and Holter *et al.* (1975) for the Scollard Member.

D. COMPONENTS OF A COAL ANALYSIS

A complete coal analysis generally consists of a proximate analysis, a calorific value determination and an ultimate analysis.

Proximate analyses involves the determination of moisture, ash, volatile matter and fixed carbon, with each component expressed as a percentage of the sample. These components can be expressed or reported in a number of ways, depending on the moisture value used. Samples expressed to an *as received* basis use the moisture value of the coal as it was submitted to the laboratory. The *as determined* basis of reporting uses the moisture value obtained during the analysis. The difference between these moisture values occurs because coal samples are generally dried before they are analyzed. Both *as received* and *as determined* moisture contents are provided in Appendix 1. *Dry* basis can be calculated from either the *as determined* or the *as received* basis by removing the moisture component and calculating the remaining components to total 100 percent. *Dry ash free* basis of reporting removes both the moisture and ash of the coal, and the remaining components, volatile matter and fixed carbon, are recalculated to total 100 percent. The method used to calculate the *dry* basis and *dry ash free*

basis is further explained in Appendix 2.

Calorific values are reported in Appendix 1 in the metric form, kJ/kg. To translate these units to BTU's/lb, multiply the kJ/kg value by a conversion factor of 0.43. For comparison, calorific values can be calculated to both a *dry* and a *dry ash free* basis following methods outlined in Appendix 2.

Ultimate analysis of coal includes determination of carbon, nitrogen, hydrogen and sulfur. Oxygen, also part of an ultimate analysis, is determined by difference. When these analysis are available, they are reported on a *dry* basis in Appendix 1. The oxygen and hydrogen contents reported in an ultimate analysis do not include the oxygen and hydrogen of the sample moisture.

Equilibrium moisture or *bed moisture* values (Appendix 1) represent the moisture content of the coal *in situ* (i.e. as it occurs in the seam). All components of a proximate and ultimate analysis, and calorific value, can be recalculated to a *moist* value (equilibrium moisture basis) following the method described in Appendix 2.

In order to use the ASTM[1] rank classification system of coal (Fig. 3), it is important to distinguish between ash in coal, as determined by the test for ash, and mineral matter in coal. The ASTM classification system requires that calorific value, volatile matter and fixed carbon be expressed on a *mineral matter free*[2]

---

[1]American Society for Testing and Materials.
[2]Calorific value must be expressed on a *moist mineral matter*

Rank	Calorific Value (kJ/kg) Equal to or, Greater Than	Less Than
High Vol. Bituminous A	32564*	–
High Vol. Bituminous B	30238	32564
High Vol. Bituminous C	26749	30238
	24423	26749**
Subbituminous A	24423	26749
Subbituminous B	22097	24423
Subbituminous C	19306	22097
Lignite A	14654	19306
Lignite B	–	14654

*Also Based on Fixed Carbon and Volatile Matter
**If Agglomerating

Figure 3: ASTM classification of coals by rank.

basis. During conventional ashing of coal, dehydration (e.g. $FeSO_4.nH_2O$ to $FeSO_4$), decomposition (e.g. $CaCO_3$ to CaO), and oxidation (e.g. FeS to $FeSO_4$) occur, as well as partial loss of volatile constituents, particularly Hg, K, Na, Cl, P and S (Berkowitz, 1979, p. 49). The percent ash value obtained for the sample thus does not reflect the true mineral matter content in the sample. Stansfield and Lang (1944) claim that, on the average, ten parts of mineral matter in coal leave only nine parts ash. The Parr Formulae (Appendix 3) allow for translation of the analytical values to a *mineral matter free* basis.

In Appendix 1 and in all descriptive and statistical sections that follow, *dry ash free* basis and *mineral matter free* basis of reporting have been calculated when the percent ash value (dry basis) was less than 25 percent. As the ash content increases, the volatile matter content, when compared to the fixed carbon content, also increases, and to avoid this an ash cutoff was required. This will be discussed further in Chapter II.

The coal samples collected in 1974 and between 1976 and 1980 were analysed by Chemical and Geological Laboratories, Edmonton, and those taken in 1975, by Cyclone Engineering, Edmonton. A number of samples from the above mentioned years were also analysed by the Alberta Research Council. No attempt was made to check the repeatability or accuracy of the analytical results from the various labs. Personal

---

[2](cont'd)*free* basis and volatile matter and fixed carbon must be expressed on a *dry mineral matter free* basis.

communication (1981) with each of the labs indicated that ASTM procedures were followed in all cases.

E. METHOD OF STUDY

In order to determine the coal-bearing formation from which each of the coal samples was collected, previously published Alberta Research Council reports were searched and coal seam correlations made in these reports were noted. In general, testholes drilled during 1974 evaluated the Scollard Member, during 1975 the Horseshoe Canyon Formation, during 1976 the Belly River Group, during 1977 the Wapiti Formation, and during 1978, 1979 and 1980 the Horseshoe Canyon Formation.

In 1980 and 1981 the results of the 685 coal analyses (Appendix 1) were placed in the Alberta Research Council's Digital Vax 11/780 computer. A computer data base management system known as DATATRIEVE was used to retrieve data selectively and recalculate them to consistent bases. In order to compute both descriptive statistics on analytically determined components and component interrelationships, output from DATATRIEVE was transferred to the University of Alberta's Amdahl 470V/8 computer. Here, the MIDAS statistics package was used to generate the information contained in the tables, histograms and cross-plots that follow.

II. PRESENTATION AND DISCUSSION OF DATA

The analytical techniques used to determine moisture, ash, volatile matter and calorific value will be briefly described here. For a more detailed discussion, the reader is referred to Berkowitz (1979) and other coal handbooks.

A. DEPTH

The coals analyzed in this study were obtained from drilling programs. The depths, summarized for each coal-bearing unit in Table 1, represent the top, or shallowest depth of the sampling interval. As will be discussed later, quality characteristics of coals are related to both depth and geographic location of the sample.

Table 1 - Summary of sample depth (in metres).

Coal-bearing Unit	n	min	max	mean
Scollard Member	227	20	275	168
Horseshoe Canyon Fm	365	18	319	114
Belly River Group	41	51	250	146
Wapiti Formation	49	15	217	102

B. PROXIMATE ANALYSIS

Moisture

The most important moisture value in a coal sample is the equilibrium moisture, as it is taken to represent the *in situ* moisture of the coal. Berkowitz (1979, p. 31) describes equilibrium moisture as

> "...the amount of water that a coal will hold when fully saturated at nearly 100% relative humidity (as in an undisturbed coal seam) and thus reflects the total pore volume of the coal accessible to moisture."

Equilibrium moisture content is determined following the procedure outlined in ASTM 1492. This requires that a sample of coal be brought to 97 to 98% relative humidity (at 30 ±0.2 degrees C), weighed, dried, and weighed again to determine the amount of moisture loss.

This study, as well as previous research (Dyck *et al.*, 1980), noted an inverse relationship between equilibrium moisture content and ash content (discussed later). For this reason the descriptive statistics of equilibrium moisture content (Table 2) only consider coal samples containing less than 25% ash (D)'. The histograms of equilibrium moisture distribution, however, show all data (Fig. 4).

It should be noted that in some cases the mean of equilibrium moisture does not occupy the modal class of the

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' *dry* basis

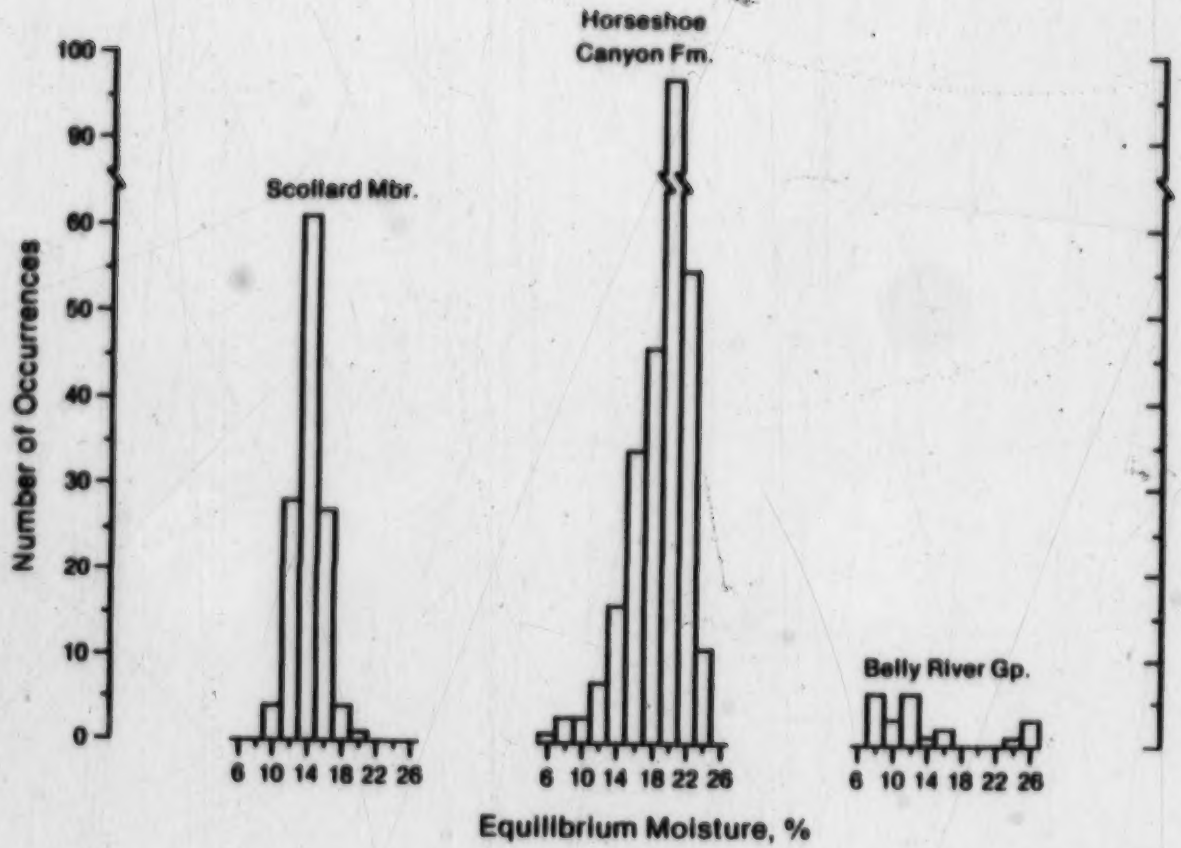

Figure 4: Distribution of equilibrium moisture values.

Table 2 - Summary of equilibrium moisture (in percent) for coals with less than 25% ash (D).

Coal-bearing Unit	n	min	max	mean	s.d.
Scollard Member	72	9.9	19.8	14.4	1.6
Horseshoe Canyon Fm	160	12.3	24.7	19.8	2.5
Belly River Group	16	8.5	26.9	14.0	6.3
Wapiti Formation	0	n/a	n/a	n/a	n/a

respective histogram (Fig. 4). This is because equilibrium moisture values are not normally distributed in the statistical sense.

Ash

Ash is the inorganic residue remaining after coal combustion (Stansfield and Lang, 1944), and is determined following the procedures outlined in ASTM 3174. A weighed sample of dried coal is combusted in excess air at a temperature of 725 (±25) degrees C, and the residue is weighed. As previously discussed, the residue remaining does not reflect the total mineral matter content of the coal. The latter is calculated using the Parr Formulae (Appendix 3).

As seen from the histograms of ash distribution (Fig. 5), the ash (D) content of coal samples varies considerably. Samples containing more than 25 percent ash are probably argillaceous coals, partings or carbonaceous shales. After all such samples were removed, descriptive

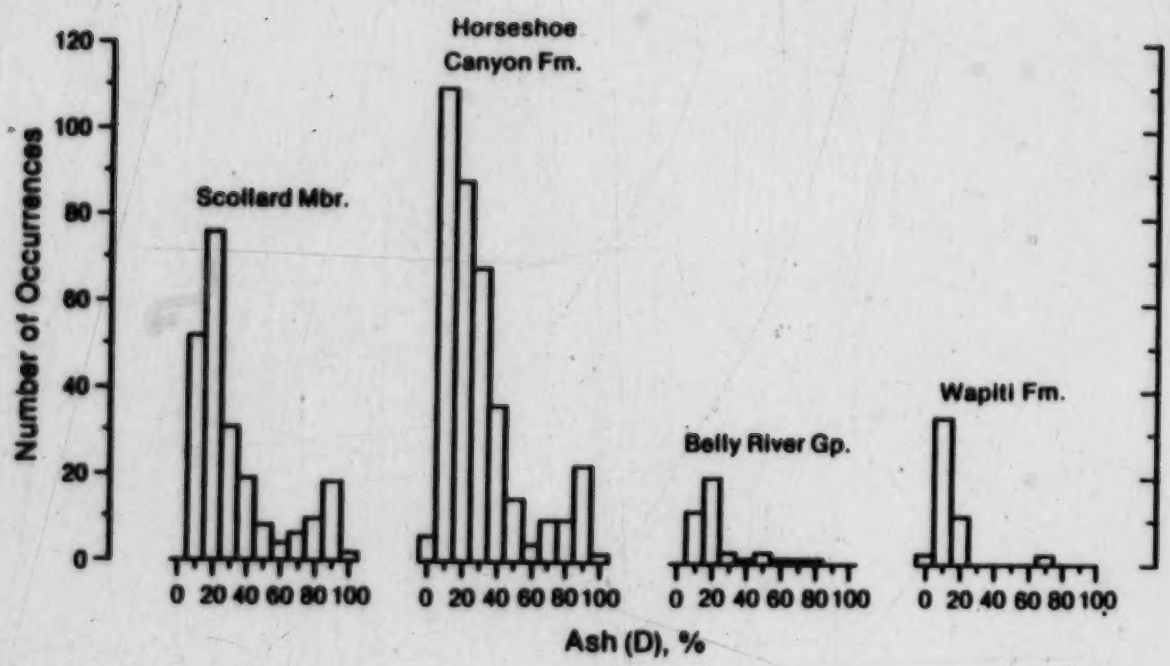

Figure 5: Distribution of ash (dry basis) values.

statistics were calculated for all coal-bearing units (Table 3).

Table 3 - Summary of ash (dry basis, in percent) for coals with less than 25% ash (D).

Coal-bearing Unit	n	min	max	mean	s.d.
Scollard Member	128	5.2	24.9	15.8	4.9
Horseshoe Canyon Fm	203	3.3	24.9	13.9	6.1
Belly River Group	32	6.9	24.7	16.6	5.9
Wapiti Formation	47	4.5	24.6	11.5	4.5

Volatile Matter

Volatile matter is the portion of the coal that is driven off during heating, and includes such substances as CO, CO_2, CH_4, tars and other hydrocarbons. It is determined following procedure ASTM 3175. A weighed sample of coal is heated in a covered crucible to 950 (±20) degrees C for 7 minutes, with care taken to prevent oxidation of the sample. The remaining sample is weighed and the weight loss, minus the weight of sample moisture, determines the volatile matter constituent of the coal.

Due to the wide distribution of ash values (Fig. 5), volatile matter and fixed carbon values should be expressed on a *dry ash free* basis for comparison. However, when calculating high ash samples to this basis, the ratio of these components to each other can become distorted, in that in progressively higher ash samples, the volatile matter content increases and the fixed carbon content decreases (Table 4).

Table 4 - Variation of the mean value of volatile matter content with respect to increasing ash content (all values in percent).

Ash (dry)	Volatile Matter (dry ash free)	Ash (dry)	Volatile Matter (dry ash free)
0 - 10	42.4	50 - 60	49.3
0 - 25	43.1	60 - 70	50.1
10 - 20	42.7	70 - 80	62.4
20 - 30	45.1	80 - 90	76.4
30 - 40	47.3	90 - 100	82.5
40 - 50	47.1		

By comparing the volatile matter content at the 0 - 10%, 10 - 20% and 0 - 25% ash levels (Table 4), it can be noted that below 25% ash, the volatile matter increase is

relatively low, compared to coals with ash contents higher than 25%. The increase in volatile matter content is due to chemically bound water in the mineral matter portion of the sample being driven off during the test for volatile matter. Clay dehydration curves (Grim, 1953) indicate that most chemically bound water is driven off at temperatures between 400 and 600 degrees C, a temperature considerably higher than encountered during the test for moisture (107 degrees C). Taking this into consideration, histograms and descriptive statistics for volatile matter (DAF)' are prepared for samples containing less than 25 percent ash (Fig. 6 and Table 5).

Table 5 - Summary of volatile matter (dry ash free basis, in percent) for coals with less than 25% ash (D).

Coal-bearing Unit	n	min	max	mean	s.d.
Scollard Member	124	34.1	58.3	40.6	3.7
Horseshoe Canyon Fm	197	34.6	65.4	44.0	3.6
Belly River Group	32	39.2	48.4	44.6	2.3
Wapiti Formation	47	39.9	49.2	44.2	2.3

'*dry ash free* basis

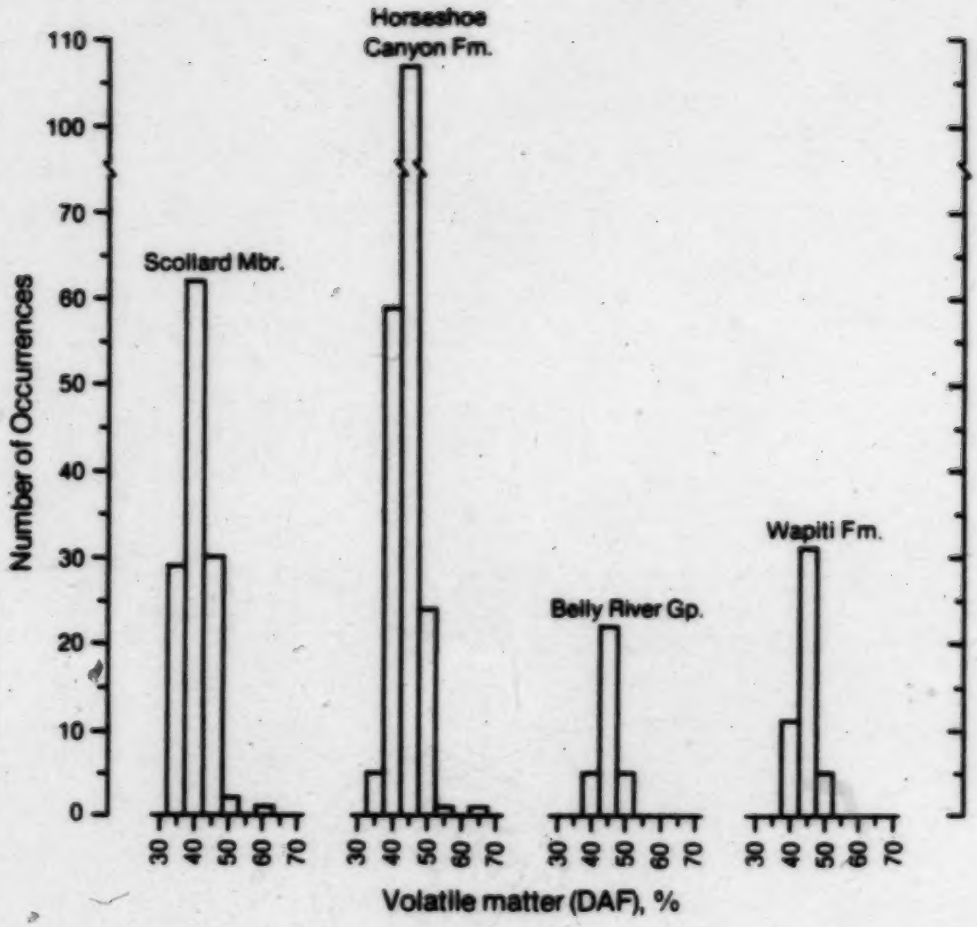

Figure 6: Distribution of volatile matter (dry ash free basis) values.

Fixed Carbon

The term fixed carbon is used to describe that portion of coal remaining after moisture, volatile matter and ash have been removed. It is calculated by

$$\%FC = 100 - (\%moisture + \%ash + \%VM).$$

As discussed previously (and in Appendix 2), values for volatile matter and fixed carbon, expressed on a *dry ash free* basis or a *dry mineral matter free* basis, total 100 percent. The descriptive statistics for fixed carbon (Table 6), therefore, are related to those of volatile matter. Only coal samples containing less than 25% ash (D) are considered.

Table 6 - Summary of fixed carbon (dry ash free basis, in percent) for coals with less than 25% ash (D).

Coal-bearing Unit	n	min	max	mean	s.d.
Scollard Member	124	41.6	65.8	59.3	3.7
Horseshoe Canyon Fm	197	34.5	65.3	55.9	3.6
Belly River Group	32	51.5	60.7	55.3	2.3
Wapiti Formation	47	50.7	60.0	55.7	2.3

C. CALORIFIC VALUE

Calorific value of a coal sample is determined following the procedure outlined in ASTM 2015. This requires that a weighed sample of coal be combusted in a calorimeter, with the calorific value of the coal sample being equated to the resulting rise in water temperature. Values are expressed in kilojoules per kilogram of coal.

In order to use the ASTM classification of low rank coals (Fig. 3), calorific values must be expressed on a *moist mineral matter free* basis. Descriptive statistics for these calorific values, as well as for calorific values expressed on a *dry ash free* basis, are presented in Table 7.

Table 7 - Summary of calorific value (in kJ/kg) for coals with less than 25% ash (D).

Coal-bearing Unit	base	n	min	max	mean	s.d.
Scollard Member	MMMF	72	22,653	27,538	25,479	796
	DAF	128	28,084	31,599	29,926	636
Horseshoe Canyon Fm	MMMF	155	20,204	27,130	23,048	1245
	DAF	197	27,433	32,769	29,315	868
Belly River Group	MMMF	16	20,104	29,356	26,065	2974
	DAF	32	26,465	32,094	29,226	1749
Wapiti Formation	MMMF	0	n/a	n/a	n/a	n/a
	DAF	47	26,349	32,394	28,345	849

The distribution of calorific values, expressed to the above mentioned bases, are provided in Figures 7 and 8. In these histograms and descriptive statistics, only coal samples containing less than 25 percent ash were considered.

As can be noted from Table 7, the coals discussed range in rank from subbituminous C to high volatile bituminous C. The mean carbon (DAF) content of these coals varies from 73.8% for subbituminous C coals to 76.9% for high volatile bituminous C coals. In order to determine an estimate of the vitrinite reflectance values that would be expected for coals of these ranks, the values of carbon (DAF) content calculated were applied to a vitrinite reflectance versus carbon content relationship provided by Berkowitz (1979). This relationship indicates that the vitrinite reflectance values for these coals should range from 0.41 to 0.51%.

D. ULTIMATE ANALYSIS

Sulfur

Because of the association of burning high sulfur coals and environmental pollution, there is considerable interest in the sulfur content of coals. The total sulfur content, both organic and inorganic, was determined for a significant proportion of the samples. These contents are reported on a *dry* basis in Appendix 1 and Table 8.

The sulfur (D) distributions for the Scollard Member, Horseshoe Canyon Formation and the Wapiti Formation are

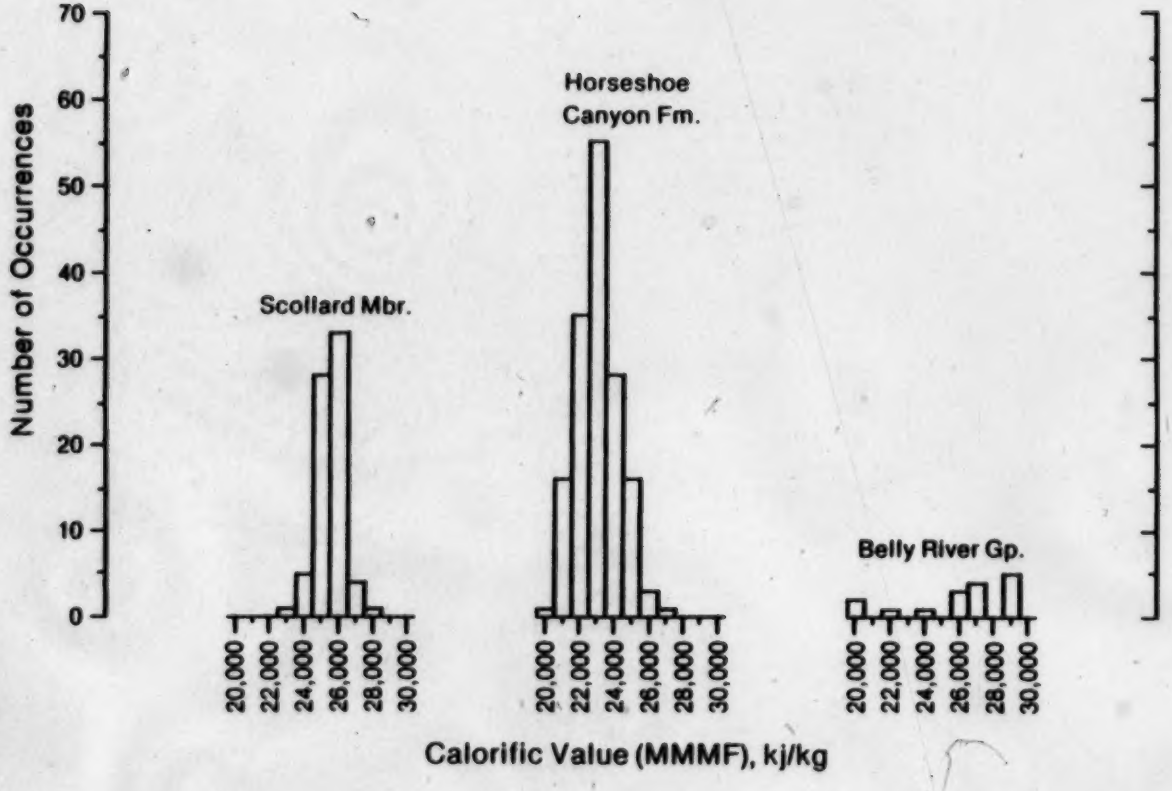

Figure 7: Distribution of calorific value (moist mineral matter free basis) values.

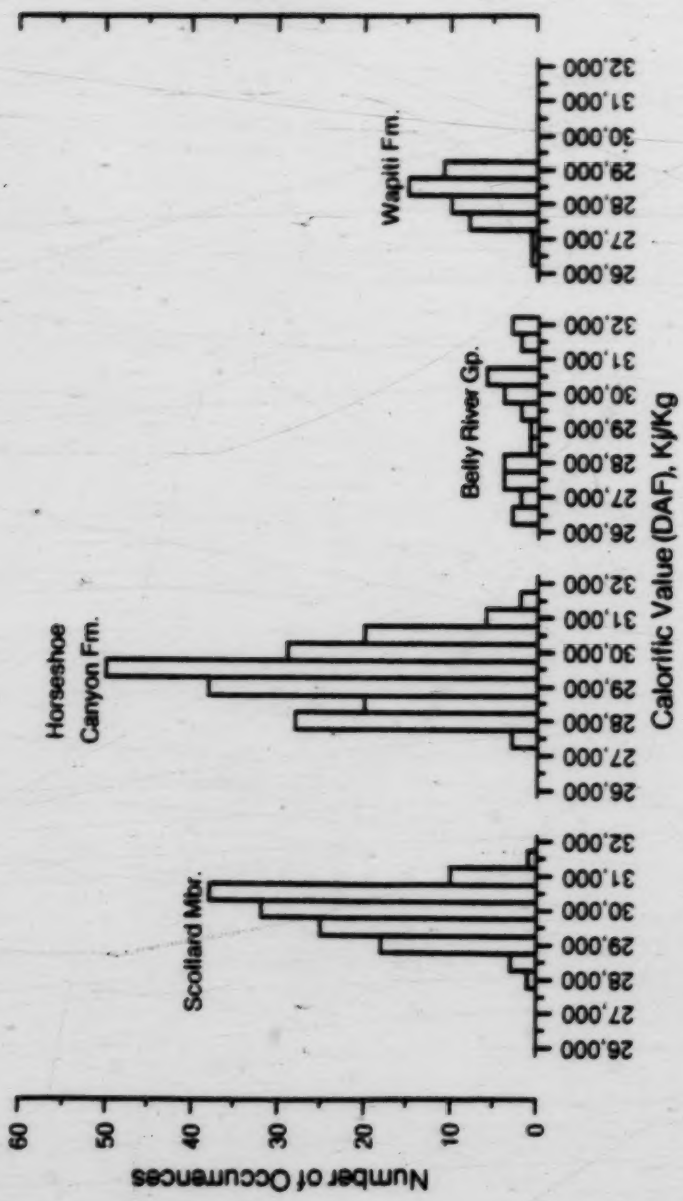

Figure 8: Distribution of calorific value (dry ash free basis) values.

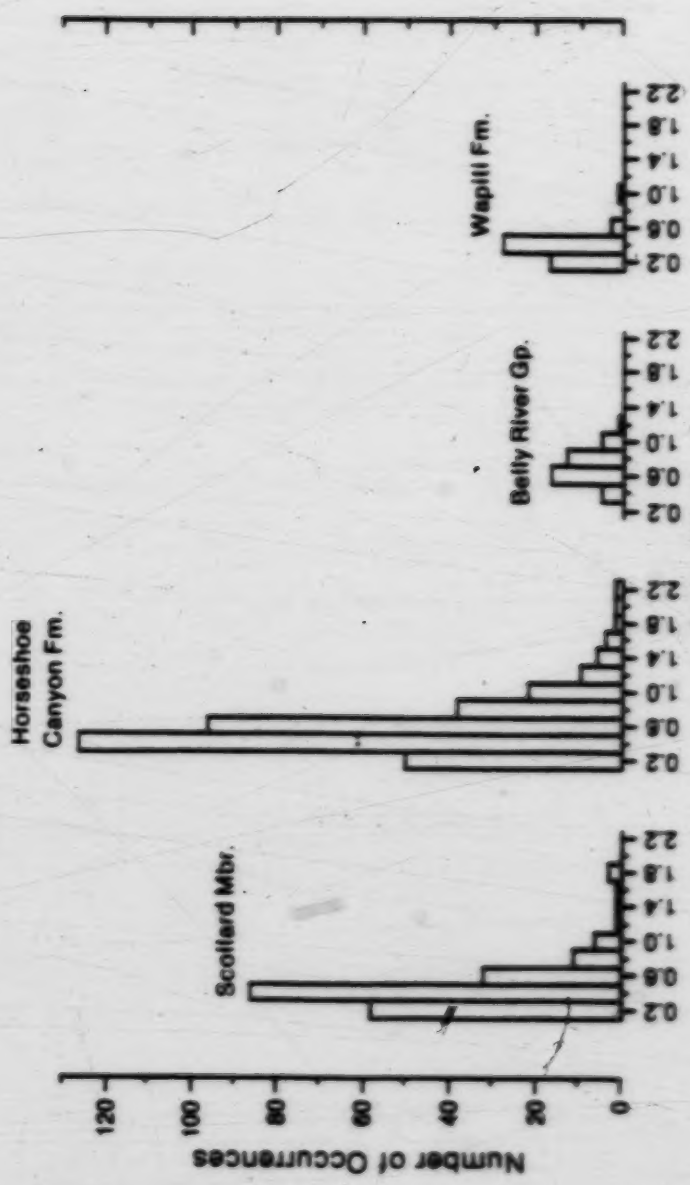

Figure 9: Distribution of sulfur (dry basis) values.

Table 8 - Summary of sulfur (dry basis, in percent) for all coals.

Coal-bearing Unit	n	min	max	mean
Scollard Member	199	0.15	1.79	0.39
Horseshoe Canyon Fm	358	0.03	2.80	0.47
Belly River Group	41	0.33	1.19	0.66
Wapiti Formation	49	0.11	0.95	0.32

95% confidence interval on the mean.

Scollard Member	0.36 to 0.41
Horseshoe Canyon Fm	0.44 to 0.50
Belly River Group	0.60 to 0.72
Wapiti Formation	0.29 to 0.35

positively skewed with a positive kurtosis (Fig. 9). The reason the Belly River Group does not have a similar distribution may be a function of the number of samples. More normal distributions occur if the sulfur percentages are transformed to their log[10] values. The minimums, maximums, means, and 95 percent confidence interval about the sample means, presented in Table 8, are calculated from the transformed data.

Carbon, Hydrogen, Nitrogen and Oxygen

The mean value of carbon, hydrogen, nitrogen and oxygen, on both a *dry* and *dry ash free* basis, are presented for each of the coal-bearing units in Table 9. The number of

analyses performed for these components was too few to permit the calculation of meaningful descriptive and comparative statistics.

Table 9 - Mean value of ultimate analysis components (in percent) for all coals.

Coal-bearing Unit	base	C	H	N	O
Scollard Member	DRY	62.7	3.8	1.0	15.0
	DAF	75.6	4.6	1.2	18.2
	n	37	37	26	26
Horseshoe Canyon Fm	DRY	60.5	4.1	1.2	14.7
	DAF	74.5	5.1	1.5	18.3
	n	53	53	39	39
Belly River Group	DRY	57.7	3.9	1.5	12.5
	DAF	74.7	5.1	1.9	15.6
	n	10	10	4	4
Wapiti Formation	DRY	63.8	4.3	1.3	19.1
	DAF	71.9	4.8	1.5	21.5
	n	4	4	4	4

E. COMPARISON OF RESULTS FROM CUTTINGS AND CORE SAMPLES

The analyses used in this study were of samples collected from both cuttings and cores from conventionally drilled testholes. Cuttings were subjected to a 1.8 specific gravity separation with the less than 1.8 specific gravity fraction analysed. This was done to remove the non-coal contamination portion of the sample. Core samples were analysed as sampled. A statistical bias limiting meaningful comparisons between the two sample types occurs when the above is taken into consideration. The ash content is artificially lowered in the cuttings samples (cuttings mean = 22.1 %, core mean = 34.3 %); thus all parameters relating to ash content, particularly calorific value (as will be discussed later), will also be affected in the comparison. Rank determination, however, will be unmarred by this sampling method, as the calorific value is calculated to a *mineral matter free* basis.

A statistical comparison of the two sampling methods will not be attempted here. The interested reader is referred to Dyck *et al.* (1980) for their discussion of a similar comparison.

III. DATA INTERRELATIONSHIPS

A. CALORIFIC VALUE VERSUS ASH

A close inverse relationship exists between the calorific value of a coal sample and its corresponding ash content. A crossplot of these variables, both expressed on a *dry* basis, is provided in Figure 10. All data with ash (D) content less than 25% are plotted, regardless of coal-bearing unit. A least square regression analysis of calorific value (D, kJ/kg) on ash (D, %) yields the equation[1]

$$CV(D) = 29269 - 286(ASH[D]) \quad (1).$$

The correlation coefficient (R) between these variables is -0.89 (with $R^2 = 0.78$), and the 95 percent confidence interval on calorific value estimation, following the method described in Ezekiel and Fox (1959, Fig. 2.1), is ± 1642 kJ/kg (706 Btu/lb).

The calorific value data shown in the crossplot (Fig. 10), and used in calculating the relationship between calorific value and ash, are from the entire plains area; thus the constant shown in Equation (1), representing the calorific value at a theoretically occurring zero ash value, would represent an average calorific value for near surface coals throughout the area sampled.

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[1]For Equation 1, the 95% confidence interval on the slope is ±14.6, and on the intercept is ±227.0.

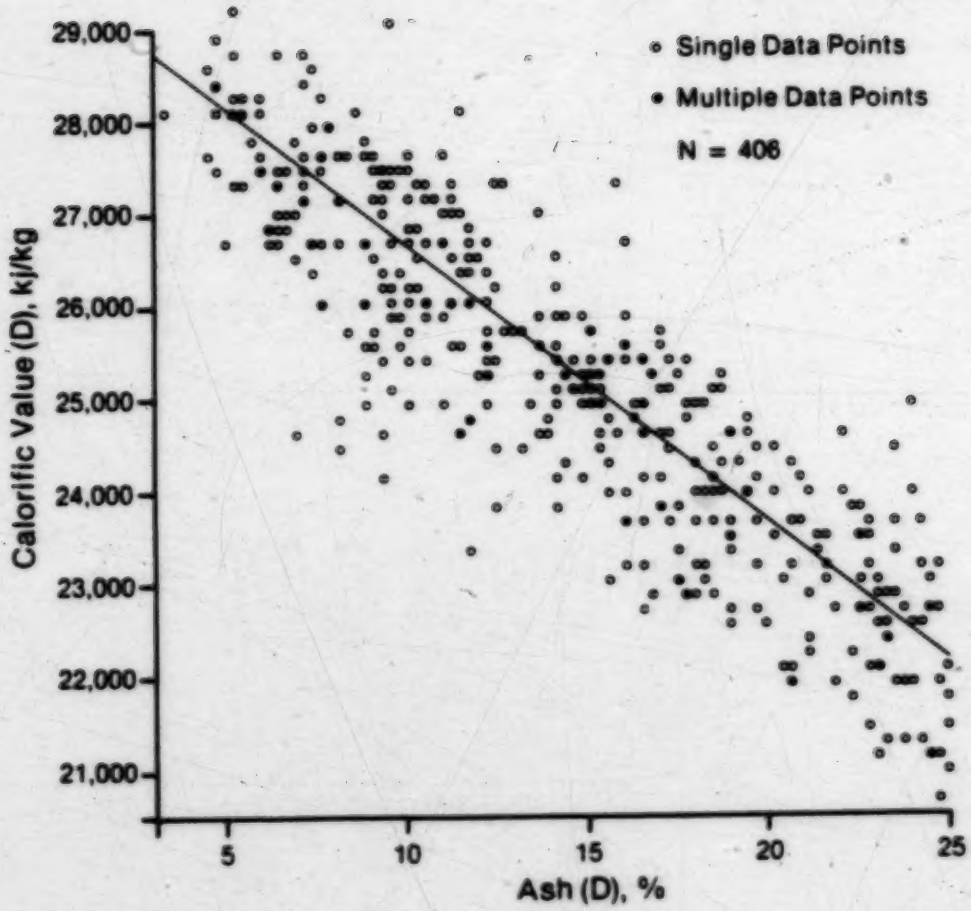

Figure 10: Crossplot of calorific value (dry basis) versus ash (dry basis).

The slope component of Equation (1) indicates that *dry* calorific value decreases by 286 kJ/kg (123 Btu/lb) per percent increase in ash (D) content.

Table 10 shows the results of both correlation coefficient and least squares regression analysis calculations for each of the coal-bearing units. Of particular interest is the lower correlation coefficient between ash and calorific value for the Belly River Group (R = -0.65) compared to the remaining coal-bearing units (with R = -0.87 to -0.94). The reason this occurs may be that the Belly River Group coals were sampled over a considerable area in an east - west direction, from township 3, range 2 W4M to township 9, range 22 W4M (Fig. 2), whereas Horseshoe Canyon Formation and Scollard Member coals were sampled in a narrow north - south band following the outcropping edge of the formation. The east - west variation in the Belly River Group samples introduces a change in calorific value because of increasing rank (hence an increasing degree of maturation) in a westerly direction. Therefore, locations of Belly River Group samples affect the ash / calorific value relationships more than for other coal-bearing units.

B. EQUILIBRIUM MOISTURE VERSUS ASH

The calculated correlation coefficient (R) between equilibrium moisture and ash (D) content is -0.38, which indicates that samples with higher ash have lower

Table 10 - Equations relating calorific value (dry basis, in kJ/kg) and ash (dry basis, in percent) for coal samples containing less than 25% ash.

Coal-bearing Unit	n	R	Equation
Scollard Member	128	-0.94	CV=29955-301(ASH)
Horseshoe Canyon Fm	197	-0.94	CV=29668-318(ASH)
Belly River Group	32	-0.65	CV=27720-203(ASH)
Wapiti Formation	47	-0.87	CV=28375-286(ASH)

equilibrium moisture. This value of correlation coefficient (R = 0.38) is statistically significant with 419 samples used in its calculation.

Dyck *et al.* (1980) calculated a correlation coefficient of -0.90 for equilibrium moisture and ash (D) content, using 1176 samples of Saskatchewan lignites. This is considerably higher than the correlation coefficient calculated in this study. A possible reason for this will be discussed later.

C. CALORIFIC VALUE VERSUS EQUILIBRIUM MOISTURE

The calorific value of a coal sample, expressed on a *moist mineral matter free* basis is affected by the equilibrium moisture of the sample, thus correlation between calorific value (MMMF)' and equilibrium moisture is to be expected. A correlation coefficient (R) of -0.91 (R^2 = 0.83) was calculated for these variables for all data regardless of coal-bearing unit. A cross-plot of these variables is

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'*moist mineral matter free* basis.

presented in Figure 11. A least squares regression analysis of calorific value (MMMF, kJ/kg) on equilibrium moisture (MEQ, %) yields the equation[1]

$$CV(MMMF) = 31816 - 442(MEQ) \quad (2).$$

The 95 percent confidence interval on calorific value estimation is ± 1408 kJ/kg (605 Btu/lb).

This relationship (as shown in Fig. 11) indicates the significant degree to which moisture content and coal rank are inter-dependent in low rank coals. Teichmüller *et al.* (1968, p. 248) similarly state that

> "...according to recent work the moisture content and the moisture-holding capacity of ash-free coal, as well as its calorific value which depends to a large degree upon the moisture content, remain the best rank indicators up to the stage of high-volatile B and A coals".

The slope component of Equation (2) indicates that calorific value (MMMF) decreases by 442 kJ/kg (190 Btu/lb) per percent increase in moisture content.

D. VOLATILE MATTER AND FIXED CARBON VERSUS CALORIFIC VALUE

The correlation coefficient (R) between volatile matter (DAF) content and calorific value (DAF) is -0.31, indicating that an increase in calorific value is associated with a

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[1]For Equation 2, the 95% confidence interval on the slope is ±25.2, and on the intercept is ±456.8.

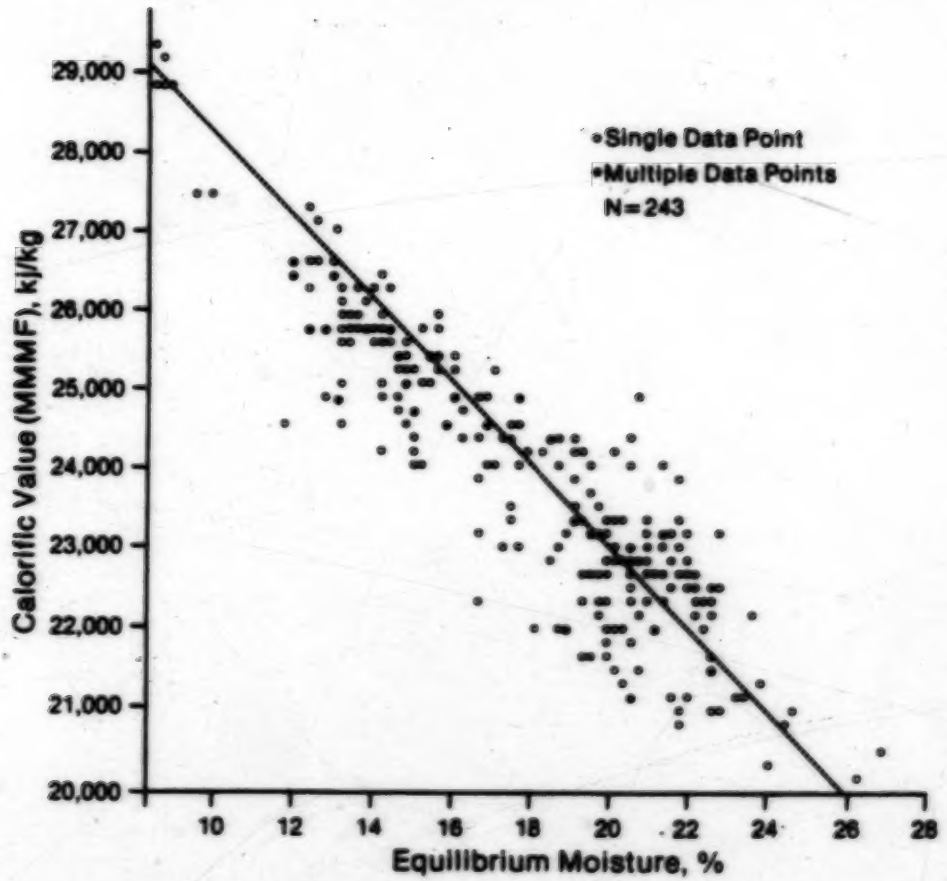

Figure 11: Crossplot of calorific value (moist mineral matter free basis) versus equilibrium moisture.

decrease in volatile matter content (or conversely with an increase in fixed carbon content).

These relationships have been known for some time and are discussed in detail by Teichmüller *et al.* (1968) and Berkowitz (1979). The values of correlation coefficient ($R = \pm 0.31$) are statistically significant with $n = 402$.

IV. ANALYSIS OF RESULTS AND PREDICTIVE MODELS

Hilt's rule indicates that in undisturbed strata, the rank of coal increases with increasing depth of burial, and this relationship has been discussed by many authors (Berkowitz, 1979; Hacquebard, 1977; Stach *et al.*, 1975; Teichmüller *et al.*, 1968). In undisturbed strata an increasing depth of burial facilitates coalification in two ways, by increasing temperature, at a rate equal to the geothermal gradient, and by compaction, through increasing overburden pressure. The increasing temperature is considered to be responsible for chemical maturation (Berkowitz, 1979) and the degree of maturation can be determined by measuring the vitrinite reflectance. Reflectance data, unfortunately, were not available for the coals discussed in this study. Thus comparing the regional coal maturation levels attained, and determining the maximum paleotemperatures to which the coals were subjected (through the use of Karweil's (1956) relationships), were not possible.

A very rough estimate of the minimum temperature required to mature the highest rank coals in this study can be obtained from Bostick (1979). Bostick (1979) provides the minimum paleotemperatures required to mature coals to various degrees of reflectance values (starting at 0.48% reflectance). As was earlier determined, the coals in this study could have vitrinite reflectance values as high as 0.51%. This value of reflectance corresponds to a minimum

paleotemperature of 107 degrees C. It should be noted that Bostick (1979) suggests the table should be used for coals Mesozoic and older in age. The high volatile bitminous C coals in this study vary in age from late Mesozoic to early Cainozoic (Campanian to Paleocene), so the minimum temperature estimated should be used with caution. The estimate of minimum paleotemperature from Bostick (1979), however, is similar to the calculated paleotemperature using the equation

$$T = 302.97(\log[10]R_o) + 187.33$$

from Price (1983), which is 99 degrees C. Contrary to many coalification models, Price (1983) disregards time as an important function during coalification, and the difference between the two temperatures (107 versus 99 degrees C) may be related to this matter.

The previous discussions on estimating paleotemperatures are based on estimates of vitrinite reflectance values from carbon (DAF) contents. Because actual reflectance values were not available, this study did not investigate the chemical changes that accompany increases in temperature. However, the data are available for studying the increases in rank due to compaction, which, in a tectonically quiescent setting such as the plains area of Alberta, should be a function of the depth of coal seam burial.

The relationship between increasing rock density (or decreasing pore volume) and increasing depth of burial has been noted by many authors (Magara, 1976; Till, 1974; Teichmüller and Teichmüller, 1968) and similar compaction phenomena should occur in coals. Berkowitz (1979) associates equilibrium moisture content with porosity (pore volume) and Hacquebard (1977) relates decreases in equilibrium moisture content to increases in original depth of burial[1] (Fig. 12)[2]. Using this relationship, and equilibrium moisture data from Steiner *et al.* (1972), Hacquebard (1977) calculated the thickness of removed sediment over oil and gas fields in Alberta. This study, using a regionally distributed and recently collected data base, will try to expand the area over which the thickness of eroded sediment can be calculated, and relate this original thickness of sediment to the rank variation patterns noted in the plains area of Alberta today.

Hacquebard's (1977) graph (Fig. 12) indicates a logarithmic decrease in bed moisture (equilibrium moisture [MEQ, %]) with respect to an increase in depth of burial (DOB, m). By estimating values from both axes of the graph, this graph can be translated to the formula

$$\log[10]MEQ = 1.865 - 0.000416(DOB) \quad (3).$$

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[1]Also see Teichmüller and Teichmüller for relationships of equilibrium moisture, depth of burial and rank.
[2]The data used by Hacquebard (1977) to construct the depth of burial / moisture relationship (provided in this study as Figure 12) was derived from European research.

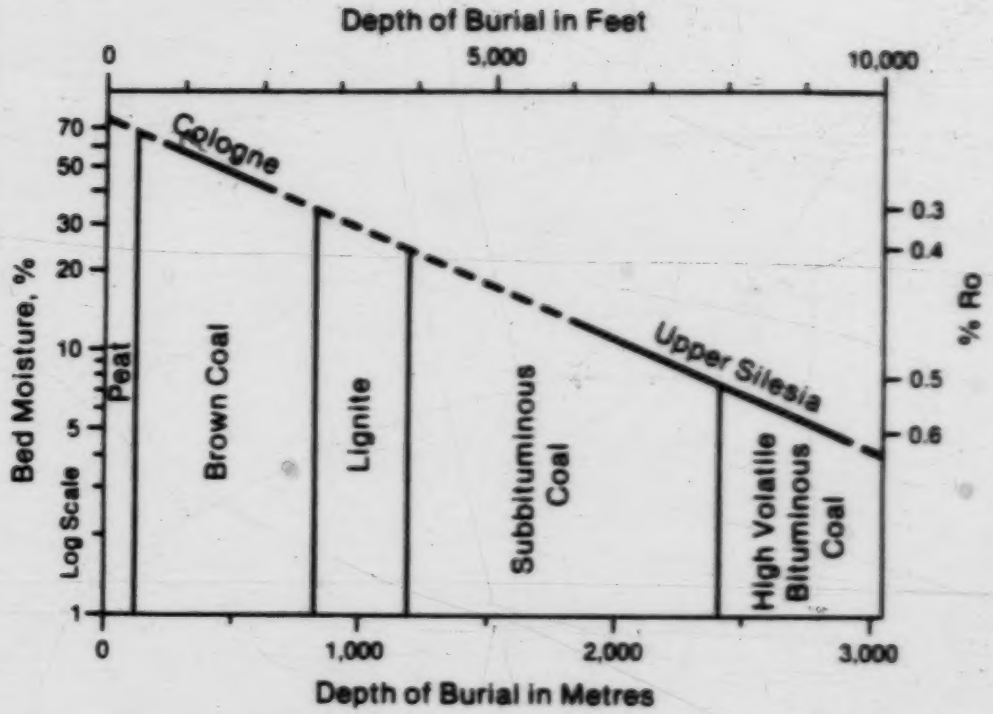

Figure 12: Relationship of moisture content in coal and its original depth of burial (from Hacquebard, 1977).

It should be noted that the coal rank divisions indicated in Figure 12 are slightly different from those encountered in this study. The relationship between equilibrium moisture and depth of burial for coals in the Alberta plains coal will be discussed later.

Using Equation 3, the original depth of burial was calculated for all coal samples with ash contents less than 25% for which equilibrium moisture data were available. A cross-plot of calorific value (MMMF) versus the calculated depth of burial (Fig. 13) follows Hilt's rule, namely, that with an increase in depth of burial, coal increases in rank. Hacquebard (1977) indicated a logarithmic relationship between equilibrium moisture and original depth of burial (Fig. 12, Equ. 3), and the present study documents an inverse linear relationship between equilibrium moisture and calorific value (MMMF). Therefore, the relationship between original depth of burial and calorific value should not be linear. However, because of the small range of depth of burial values calculated (1200 to 2200 m [3937 to 7218 ft]), the relationship appears linear, (especially for the calorific range 22000 to 29000 kJ/kg) and a simple least squares regression analysis can be performed. Results of this regression analysis yields the equation

$$CV(MMMF) = 14748 + 6.25(DOB) \quad (4).$$

The slope component of this equation indicates that plains

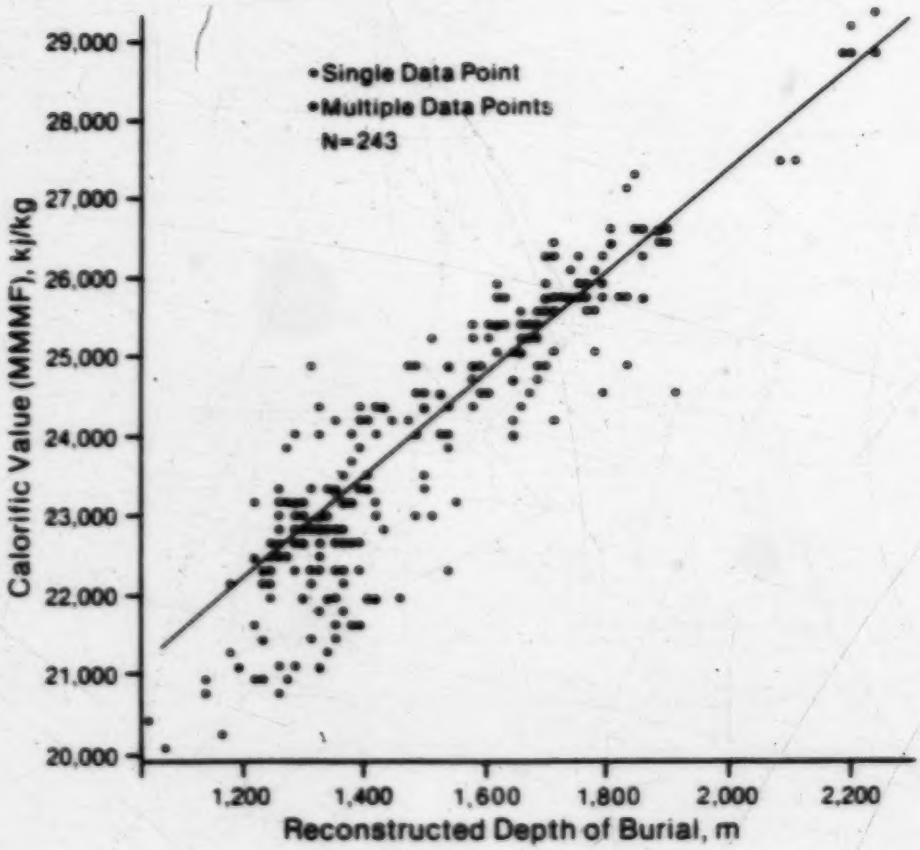

Figure 13: Crossplot of calorific value (moist mineral matter free basis) versus original depth of burial.

coals increase in calorific value (MMMF) at a rate of 6.25 kJ/kg per metre (0.82 Btu/lb/ft) of depth (or overburden). This rate of increase represents the coalification gradient. Equation (4) or the coalification gradient should not be used for coals with ranks beyond the calorific value range of 22000 to 29000 kJ/kg because of the curvilinear relationship between depth of burial and coal rank.

Campbell (1972), using coal samples from deeper oil wells, calculated a coalification gradient of 5.34 kJ/kg per metre (0.7 Btu/lb/ft) for the Alberta plains area. This lower gradient, however, was calculated on the basis of an assumed linear relationship between rank and depth, for the range of coal ranks between subbituminous and low volatile bituminous. As discussed previously, however, the assumption of a linear relationship for such a considerable calorific value range cannot be made.

With the use of Equation (4), the overburden required to produce various low rank coals can be calculated (Table 11). This equation can also be used to modify Hacquebard's (1977) diagram (Fig. 12) to include the coal ranks found in the Alberta plains (Fig. 14).

It should be noted that in order for this relationship to hold true, sediment deposition between the oldest and youngest coals discussed (Belly River Group and Scollard Member, respectively) would have to have been generally continuous, without major periods of erosion. The effect of

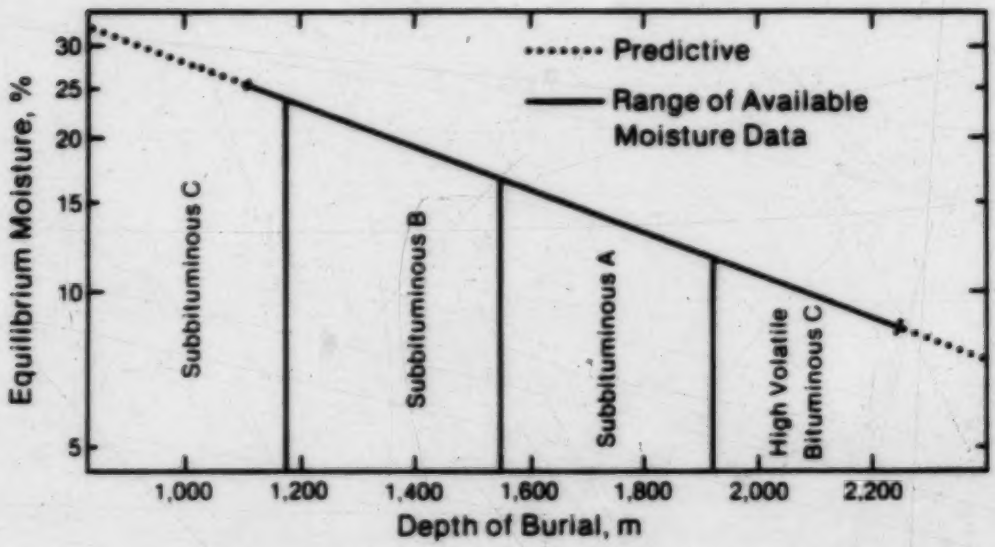

Figure 14: Modification of Hacquebard's (1977) diagram, including the coal ranks found in the plains area of Alberta.

TABLE 11 - Required thickness of overburden to mature coals. The calculation for subbituminous A coal assumes that the coal is non-agglomerating.

Coal Rank (ASTM)	Required Overburden (metres)
Subbituminous C	---- - 1176
Subbituminous B	1176 - 1548
Subbituminous A	1548 - 1920
H V Bituminous C	1920 - ----

a major period of deposition, and subsequent erosion, would be that the coals underlying the erosion surface would have anomalously higher ranks, as compared to coals overlying the erosion surface. This would occur because the coals from below and above the erosion surface would have had different compaction histories, and thus reached their peak maturities at different times. Major unconformities, which would reflect periods of significant erosion, have not been recognized within the stratigraphic section being discussed. Therefore, in a vertical section (for example, a borehole), it is assumed that all coals reached their maximum (and current) level of maturation at the same time; this time being at a point when their depth of burial was greatest.

Once the original depth of burial of a coal sample has been calculated, the amount of sediment removed above the coal sample can be determined by subtracting the present depth of the sample from its original depth of burial. In

order to present this data in map view, and to remove some of the statistical variation in the data, the coal-bearing portion of the plains (as defined by Fig. 1) was divided into blocks, each nine townships in area (840 km² [324 mi²]), and an average value of removed overburden calculated for each block (Appendix 4). These values were then plotted and contoured (Fig. 15).

As is shown in Figure 15, the amount of overburden removed varies from approximately 900 m (2,953 ft) in the east to approximately 1900 m (6,234 ft) in the west part of the plains area.

Suggate and Lowery (1982) note that coals with similar equilibrium moisture contents have higher ranks in areas with higher geothermal gradients compared to coals from areas with lower geothermal gradients. As discussed in this thesis, coals with similar equilibrium moistures must have been subjected to similar compaction histories (or similar depths of burial). The reason, therefore, that coals from areas with higher geothermal gradients are higher in rank would be because these coals reached higher levels of chemical maturation. Comparing figures 12 and 14, the coals occurring in the plains area of Alberta (Fig. 14) appear to mature at shallower depths, as compared to the coals used in the Hacquebard (1977) study (Fig. 12). This would indicate that the regional geothermal gradient, at the time of maximum burial, was possibly higher in the plains area of

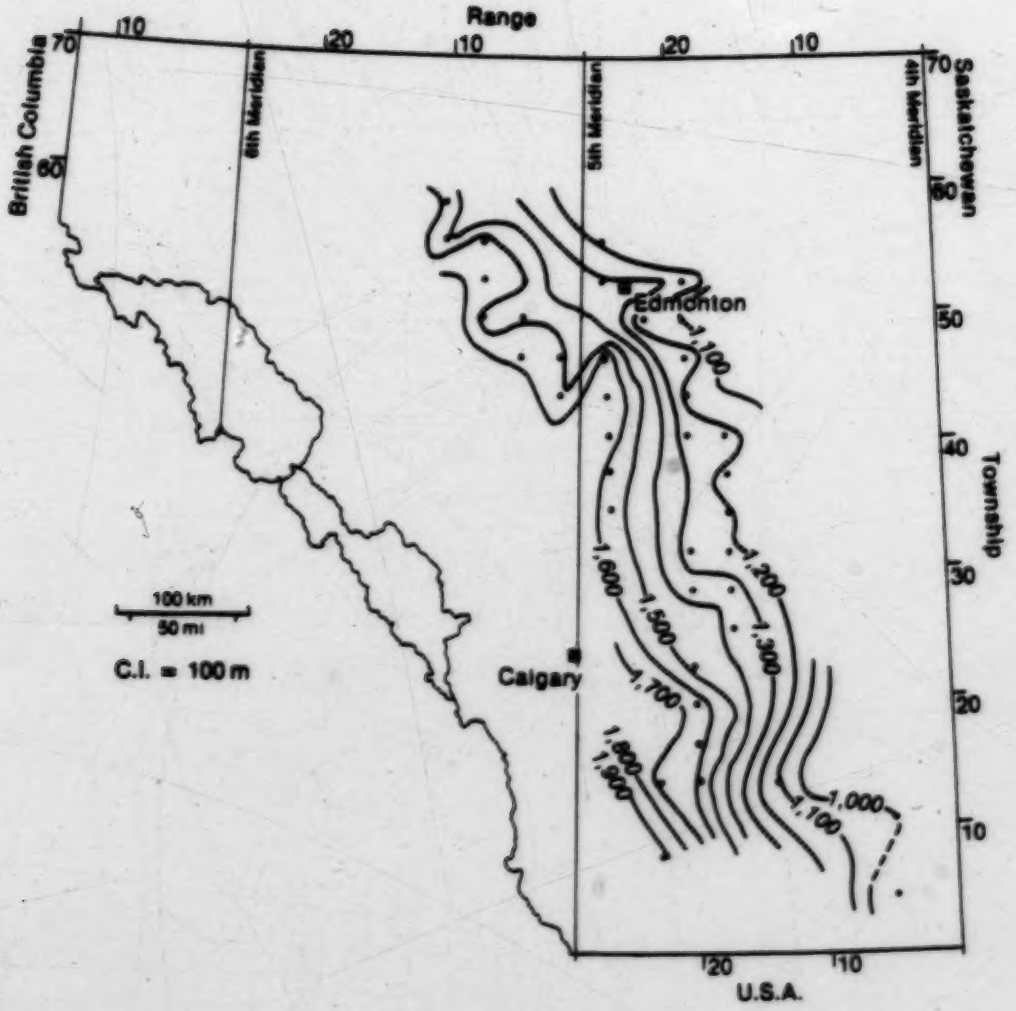

Figure 15: Thickness of removed sediment from the plains area of Alberta.

Alberta.'

The high volatile bituminous C coals in this study were subjected to an estimated paleotemperature of between 107 and 99 degrees C, using models by Bostick (1979) and Price (1983). Assuming a surface temperature of 16 degrees C for the time the maximum paleotopographic surface existed (Hacquebard, 1977), and using a depth of burial of 1920 m (6299 ft) for coals that have an estimated vitrinite reflectance of 0.51%, these temperatures translate to a paleogeothermal gradient of between 47.3 and 43.2 degrees C per km of depth. These gradients are considerably higher than would be expected. Possible reasons for these high estimates are: 1) the models provided by Bostick (1979) and Price (1983) are incorrect, or do not apply to the plains area of Alberta, 2) the estimate of vitrinite reflectance from Berkowitz (1979) is too high for the coals discussed, or, 3) the thicknesses of overburden estimated are less than the actual thicknesses that existed. Further work on the reflectance of plains coals is required in order to provide more detailed information on paleogeothermal gradients.

Cross-section AA' (Fig. 16) is constructed through the plains, from northeast to southwest (Fig. 1), and indicates the subsurface stratigraphy, the westerly dip of the

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'For reference, the present geothermal gradient in the plains area of Alberta decreases from east to west, from approximately 33 degrees C to 22 degrees C per km (United States Geological Survey, 1976), and Hitchon (in press) suggests that this geothermal gradient pattern existed since early Eocene time.

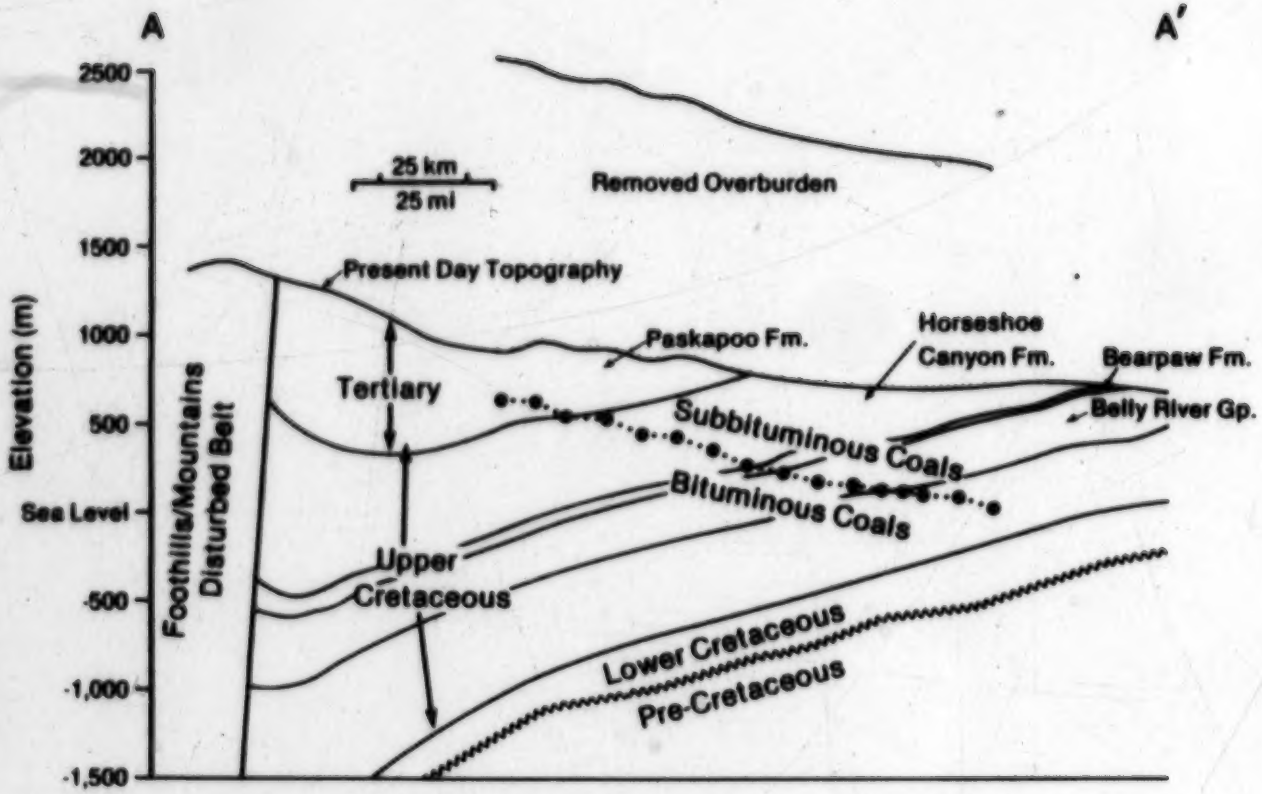

Figure 16: Cross-section AA' (see Fig. 1 for cross-section location), showing both the reconstructed overburden and the west southwest dip of the coal-bearing units. The subsurface stratigraphy is modified after Gussow (1962).

coal-bearing units, and the reconstructed maximum paleotopographic surface. The maximum paleotopographic surface was determined by adding the calculated amount of removed overburden to the present land surface. During the period of time when the calculated maximum paleotopographic surface existed, plains coals would have reached their maximum (and current) degree of metamorphism. As noted in Table 11, high volatile bituminous C coals require at least 1920 m (6299 ft) of burial. A line 1920 m (6299 ft) below the maximum paleotopographic surface, shown in cross-section AA' (Fig. 16), should therefore separate the occurrence of bituminous coals from subbituminous coals in the subsurface. A similar method of calculation can be used to determine the theoretical occurrence of the subbituminous ranks of coal in the subsurface. This has been done in cross-section BB', which is constructed east to west through southern Alberta (Fig. 17). As noted in both cross-sections AA' and BB' (Figs. 16 and 17), higher rank coals occur nearer the present land surface in the western part of the plains where calculations show that greater amounts of sediment have been removed.

At first glance, the thicknesses of removed overburden, as noted in Figures 15, 16 and 17, appear excessive. However, the following discussion on Tertiary stratigraphy and tectonic events may demonstrate that these thicknesses are realistic.

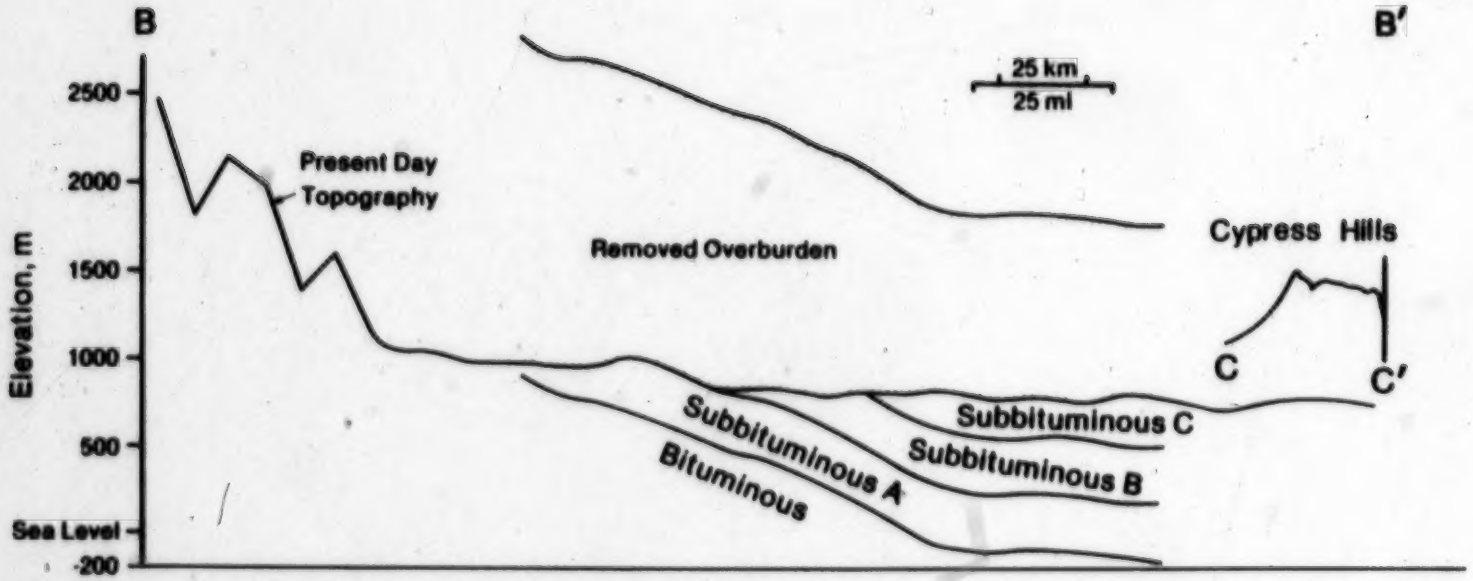

Figure 17: Cross-section BB' (see Fig. 1 for cross-section location), showing the reconstructed overburden and its relationship to coal rank in the subsurface.

Taylor *et al*. (1964) indicate that Paleocene sediments (lower Tertiary) attain a thickness of over 1500 m (4921 ft) in portions of the westernmost interior plains and it is very possible that equivalent sediments extended eastward in the past. In addition to these sediments, sediments derived from the uplift of the Rocky Mountains during the Eocene and Oligocene Epochs (Taylor *et al*., 1964), would have provided additional sediment thickness. Taylor *et al*. (1964, p. 193) state

> "...only an insignificant portion of the enormous amount of debris that moved eastward along drainage channels in Eocene and Oligocene times remains on the Canadian Plains".

Price *et al*. (1970) differ from Taylor *et al*. (1964) in their interpretation of the structural development of the eastern Rocky Mountains. They feel that the major thrusting culminated during the Paleocene, not during the Eocene and Oligocene as suggested by Taylor *et al*. (1964). The deposition of Eocene - Oligocene sediments in the plains area was, by Price *et al*. (1970, p. 23)

> "...associated with a new and different phase of deformation in the Cordillera - gravity faulting, during which block fault structures were superposed over older thrust and fold structures."

Regardless of their views on the structural development of the easternmost Rocky Mountains and westernmost plains, both authors support the idea of a blanket of Eocene -

Oligocene sediments covering the plains area. Significant portions of this Tertiary sediment, as well as portions of Upper Cretaceous sediment, were subsequently eroded, as shown by the present elevation and stratigraphy of the Cypress Hills (Fig. 1).

The east portion of cross-section BB' (Fig. 17) displays both the present surface elevation through township 13 and the elevation of the Cypress Hills, through township 8 (cross-section CC', 50 km [31 mi] south of cross-section BB'). The maximum paleotopographic surface in cross-section BB', projected easterly, would fall approximately 180 m (591 ft) above the top of the Cypress Hills. The Cypress Hills are capped with a coarse Oligocene conglomerate, and it is possible that at least 180 m (591 ft) of sediment could have been eroded from the top of the these hills during the last 30 million years.

Since the calculations of sediment removal in the vicinity of the Cypress Hills appear reasonable, the estimated sediment removed in the contoured area is probably reasonable (Fig. 15).

Geophysical logs from petroleum boreholes located in the Cypress Hills (6-3-8-2-W4M), and outside the hills (11-16-13-3-W4M) on cross-section BB', were examined to determine the thickness of rock eroded in areas away from the Cypress Hills (Fig. 18). Comparing the two boreholes, and using the Geological Map of Alberta, indicates that 45 m (148 ft) of Belly River Group, 336 m (1104 ft) of Bearpaw

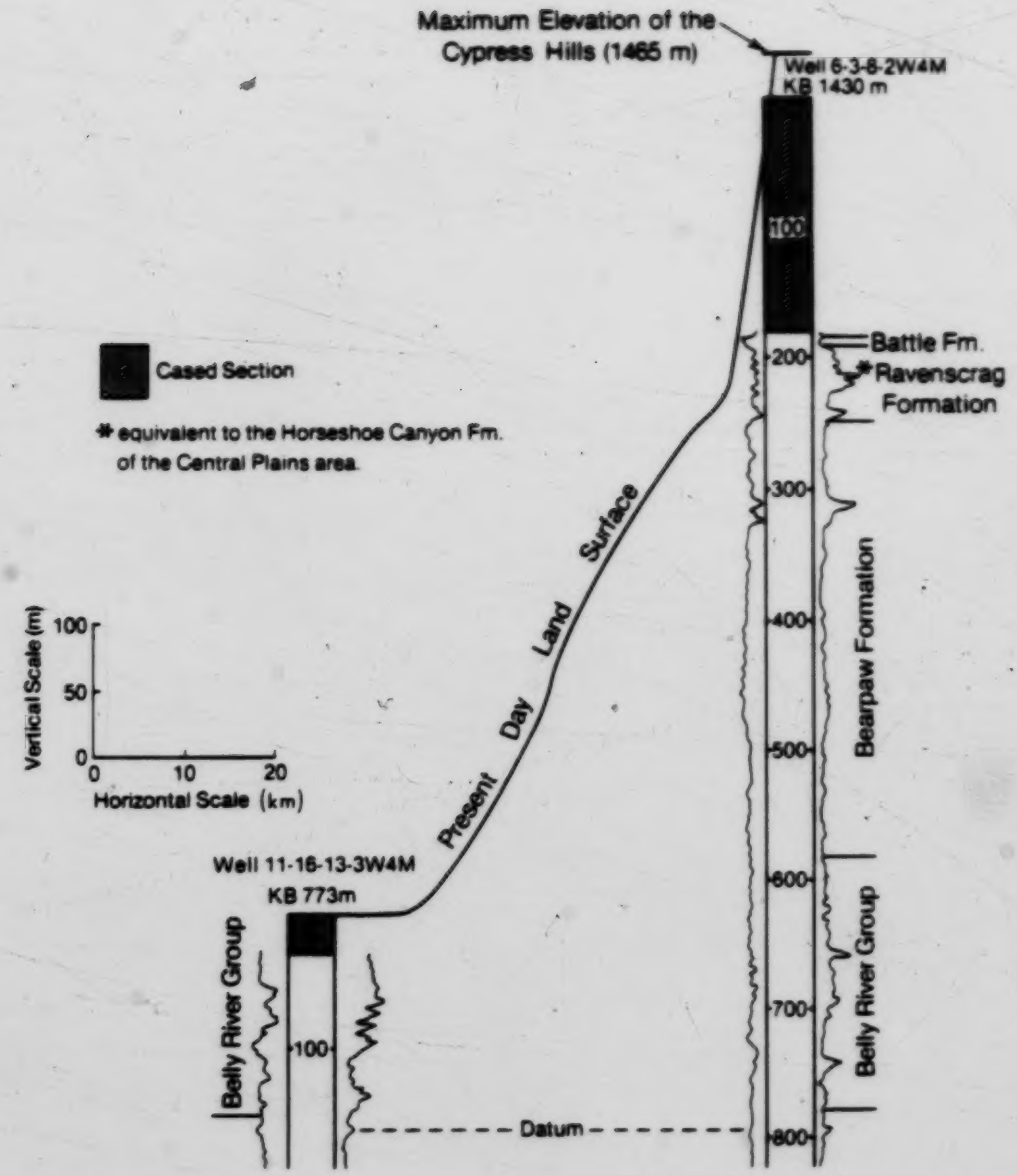

Figure 18: Cross-section DD' (see text for cross-section location), indicating the thickness of units eroded in the vicinity of the Cypress Hills.

Formation, 57 m (186 ft) of Horseshoe Canyon Formation equivalent', 7 m (22 ft) of Battle Formation, and at least 218 m (717 ft) of post-Battle Formation sediments have been removed from the vicinity of the 11-16 borehole. Because the above mentioned lithologic units are only exposed in a few wells in the Cypress Hills area, trends of formation thickening or thinning could not be determined, and calculations of sediment removal assume that all rock units remain constant in thickness. Excluding the thickness of sediment that has been removed since Oligocene time from the Cypress Hills, the calculations show that at least 678 m of sediment have been removed from the area of the 11-16 borehole.

Calculation of meaningful denudation rates require knowledge of the area of the source area, the volume of sediments derived from the source area, and the duration of the erosion (Menard, 1961). The thickness of eroded sediment calculations in this study cover only a portion of a drainage basin, thus the volume of sediments removed from the drainage basin cannot be determined. Menard (1961) calculated a denudation rate of 46 mm (1.8 in.) per 1000 years for post-Jurassic erosion of the Mississippi drainage basin. Accurate paleodraingage directions for Oligocene and Eocene sediments in the plains area are not known because of the scarcity of outcrop, however, early Tertiary drainage did have a east to southeast component (Rahmani and

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'known as the Ravenscrag Formation in the Cypress Hills area, following Carrigy (1971)

Lerbekmo, 1975). If these regional paleodrainage conditions persisted through middle Tertiary time, a portion of the sediments indicated as eroded in this study would have entered the Mississippi drainage basin. Assuming an erosion time of 30 million years (middle Oligocene to present), the central plains area of Alberta underwent erosion at rates between 33 and 63 mm (1.3 and 2.5 in.) per 1000 years. These values match well with the overall denudation rates calculated for the Mississippi drainage basin.

Magara (1978), using sonic transit times in shales to estimate the degree of compaction, also calculated the thickness of sediment that was eroded from the plains of Alberta. The thickness he calculated, however, is considerably less than the thicknesses presented here (Figs. 15, 16 and 17). Magara's (1978, p. 44) cross-section III-III' trends approximately northeast in the southern part of Alberta. At a point on this cross-section, approximately 14 km (9 mi) north of the city of Medicine Hat (point M in Fig. 1), Magara (1978) calculated approximately 176 m (577 ft) of sediment erosion. The present surface elevation at this point is 732 m (2,400 ft), indicating a maximum paleotopographic elevation of 908 m (2,977 ft). The Cypress Hills, 68 km (42 mi) southeast of point M (Fig. 1), and approximately on depositional strike, have an elevation of 1465 m (4,807 ft). These two locations should have had similar elevations during Oligocene time when sediments were actively being shed easterly from the foothills and

mountains. Magara's (1978) estimation of maximum paleotopographic elevation at point M may be at least 557 m (1,827 ft) less than the possible maximum, as suggested by the present day elevation of the Cypress Hills.

Because of this discrepancy, the remainder of Magara's calculations of sediment erosion in the Alberta plains may be equally at variance with those of this study.

Coals equivalent in age to those occurring in the Scollard Member in the plains area are being mined in the Coal Valley area in the foothills (Fig. 1). Equilibrium moisture content of these coals is approximately 8.5 percent and calorific values (MMMF) vary from 27905 to 28424 kJ/kg (11,997 to 12,220 Btu/lb) (Mervyn Rogan, Luscar Ltd., per. comm., 1982). Coal quality parameters approaching these values can be noted in coal samples from Upper Cretaceous and Tertiary coals in the plains (Tables 2 and 7). If, as previously thought (Campbell, 1983; Stansfield and Lang, 1944), coal rank in the plains area of Alberta was related to heat and / or pressure generated from the uplift of the Rocky Mountains, coals in the foothills region should be considerably higher in rank than those found in the plains. This, as shown above, is not the case.

The similarity between coals found in the Coal Valley area and those found in the subsurface of the central plains area can be explained by the model for coal rank distribution presented in this study. The Coal Valley area was uplifted during Paleocene or early Eocene time (Price *et*

al., 1970; Taylor *et al.*, 1964) and thus coals in this area would not have had the maturation benefit of the overburden added during Eocene and Oligocene time. Upper Cretaceous and Tertiary coals, therefore, increase in rank in the plains from east to west because of increasing original overburden thicknesses, and then decrease in rank when encountered in the foothills region, because of thinner, or non-existent, post-Paleocene age overburden thicknesses.

In a previous section, where the relationship between equilibrium moisture and ash was discussed, it was noted that in a study of Saskatchewan lignites, equilibrium moisture content and ash content had a correlation coefficient of R = -0.90, considerably higher than the correlation found in this study (where R = -0.38). This study demonstrated that the variation in equilibrium moisture in coals from the plains area of Alberta can be related to the variation in coal seam depth of burial, which varies according to the sample location. Because of the good correlation between equilibrium moisture and ash in the Saskatchewan study, other factors affecting the lignites equilibrium moisture, such as variation in depth of burial, did not exist, or played a lesser role.

V. ECONOMIC IMPLICATIONS

The relationship between calorific value (MMMF) and depth of burial (Equation 4) was used to determine the thickness of overburden required to mature various low rank coals (Table 12). This information, combined with the map showing the thickness of removed sediment (Fig. 15), can be used both to define areas containing similar ranks of coal and to determine present depths to coals of higher ranks. As high volatile bituminous C coals require at least 1920 m (6,299 ft) of burial (Table 12), these coals should be found at or near the surface in areas where approximately 1920 m (6,299 ft) of overburden have been removed. Similarly, these coals should be found approximately 100 m (328 ft) below the surface where 1820 m (5,971 ft) of overburden have been removed. Using this method we can calculate the minimum theoretical depth to the occurrence of high volatile bituminous C coal in the plains (Fig. 19) where near-surface data exists. Although the maps are not presented here, a similar method of calculation can be used to define the occurrence of the subbituminous ranks of coal.

According to ERCB (1982), 82% of the total area underlain by coal-bearing strata in Alberta occurs in the plains area south of Lesser Slave Lake. Indications from maps and cross-sections (Figs. 15, 16 and 17) in this study are that the thickness of eroded sediment increases in a westerly direction, therefore coals occurring in that direction would increase in rank. This is in part shown by

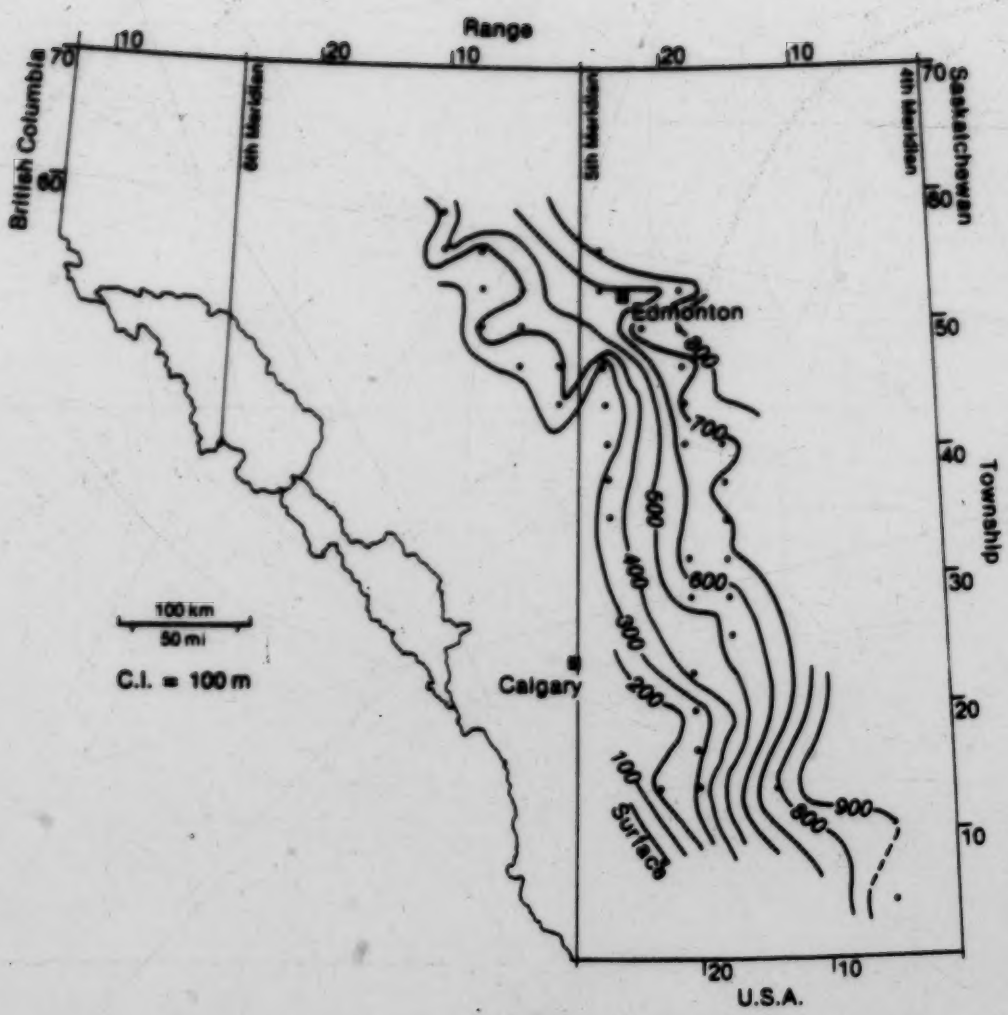

Figure 19: Calculated depth to high volatile bituminous C coals in the plains area of Alberta.

the higher average rank of Scollard Member coals versus Horseshoe Canyon Formation coals (Table 7; subbituminous A versus subbituminous B, respectively), with Horseshoe Canyon Formation coals generally sampled to the east of Scollard Member coals.

VI. CONCLUSIONS

Upper Cretaceous and Tertiary near-surface coals in the Alberta plains vary in rank from subbituminous C to high volatile bituminous C. Considering coals that contain less than 25% ash (D), equilibrium moisture averages 17.8%, ash (D) averages 14.4%, volatile matter (DAF) averages 43.0%, fixed carbon (DAF) averages 57.0%, and calorific value (MMMF) averages 23967 kJ/kg. Calorific value is highly dependent on ash and moisture content.

Coal rank in the Alberta plains increases with depth, at a rate of 6.25 kJ/kg per m (0.82 BTU/lb/ft) and increases towards the Rocky Mountains. The former increase is related to the coalification gradient and the latter to greater depths of burial. Subsequent to the coals reaching their maximum maturity in the mid Tertiary, erosion has removed between 900 and 1900 m (2953 and 6234 ft) of sediment from the plains area. Erosional outliers, such as the Cypress Hills, appear to fit the proposed erosion model.

The results of this study suggest that a significant portion of Alberta's Upper Cretaceous and Tertiary coal resources, which traditionally have been classed as subbituminous in rank, may fall into the bituminous ranks.

The hypothesis proposed in this study could be tested by sampling coals from a series of coal testholes or oil and gas wells in an east - west direction. A combination of equilibrium moisture, vitrinite reflectance and rank data from these samples would provide information on 1) the

thickness of removed strata both east and west of the present study area, 2) information on paleogeothermal gradients, and 3) the rate of rank increase with respect to both depth and geographic location.

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VII. APPENDICES

A. APPENDIX 1

COAL ANALYSIS FILE

The 685 analysis enclosed in Appendix 1 are sorted firstly by land location, from south to north, and secondly by depth. The land locations on the following pages are presented in their conventional format, namely

LSD-SEC-TWP-RGE-MER

In order to minimize the amount of space required for Appendix 1, the following abbreviations are used.

Abbreviation	units	Parameter
COAL ZONE		Coal-bearing Unit
SC-M		Scollard Member
HC-F		Horseshoe Canyon Formation
BR-G		Belly River Group
WP-F		Wapiti Formation
UNKN		Unknown unit
UPPER DEPTH	m	upper sampling depth
LOWER DEPTH	m	lower sampling depth
SAMP TYPE		sample type
CUTT		cuttings
CORE		core
MOISTURE		moisture
AD	%	as determined moisture
AR	%	as received moisture

MEQ	%	equilibrium moisture
ASH DRY	%	dry basis
VL-MATTER		volitile matter
DRY	%	dry basis
DMMF	%	dry mineral matter free basis
FX-CARBON		fixed carbon
DRY	%	dry basis
DMMF	%	dry mineral matter free basis
CAL-VALUE		calorific value
DRY	kJ/kg	dry basis
MMMF	kJ/kg	moist mineral matter free basis
ULT-ANALYSIS		ultimate analysis
S	%	sulfur, dry basis
C	%	carbon, dry basis
H	%	hydrogen, dry basis
N	%	nitrogen, dry basis
O	%	oxygen, dry basis
COAL RANK		coal rank determinations
HVB-C		high volatile bituminous C
SUB-A		subbituminous A
SUB-B		subbituminous B
SUB-C		subbituminous C
INSF		insufficient data available

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-22- 3- 2W4M	BR-G	72.8	73.7	CUTT	5.6			26.3	36.4		37.3		20008		.82					INSF
7-31- 4- 4W4M	BR-G	184.1	184.1	CUTT			26.3	16.5	34.8	40.6	48.7	59.4	23702	20106	.90	60.90	3.80			SUB-C
1-29- 5- 6W4M	BR-G	86.5	87.8	CUTT	4.3			9.4	38.7		51.9		24646		.96					INSF
13-10- 7- 7W4M	BR-G	78.0	79.2	CUTT	4.2			13.1	41.3		45.6		24446		.90					INSF
13-10- 7- 7W4M	BR-G	90.5	92.9	CUTT	7.6			8.2	39.7		52.1		24514		.44					INSF
16-21- 8- 7W4M	BR-G	163.1	164.3	CUTT	5.0			20.7	35.7		43.6		21916		.94					INSF
5-19- 9- 5W4M	BR-G	94.2	95.1	CUTT	6.2			48.2	28.1		23.7		13512		.74					INSF
1-28- 9- 7W4M	BR-G	134.1	134.1	CUTT	4.2			24.7	34.8		40.5		20655		.80					INSF
1-28- 9- 7W4M	BR-G	134.1	134.1	CUTT	3.3			23.1	35.0		41.9		21206		.92					INSF
1-28- 9- 7W4M	BR-G	134.1	134.1	CUTT			26.9	32.7	30.9		36.4		18771		.70	48.30	3.20			INSF
4-35- 9-22W4M	BR-G	189.6	190.1	CORE	2.0	17.0	8.8	74.5	14.5		11.0		6541		.34					INSF
4-35- 9-22W4M	BR-G	190.1	190.5	CORE	4.2	12.4	9.6	24.5	35.6	45.7	39.9	54.3	23086	27449	.57					HVB-C
4-35- 9-22W4M	BR-G	190.5	190.8	CORE	3.0	9.7	9.0	11.5	39.2	43.6	49.3	56.4	28012	28775	.86					HVB-C
4-35- 9-22W4M	BR-G	190.5	190.8	CORE			12.6	12.6	36.4	40.8	51.0	59.2	27331	27133	.70	68.30	4.60			HVB-C
4-35- 9-22W4M	BR-G	190.8	191.1	CORE	2.6	16.8	8.8	16.1	37.1	43.3	46.8	56.7	26649	28905	.51					HVB-C
4-35- 9-22W4M	BR-G	191.1	191.4	CORE	2.6	16.0	8.5	9.6	39.1	42.7	51.3	57.3	29015	29356	.64					HVB-C
4-35- 9-22W4M	BR-G	191.4	191.7	CORE	3.1	10.8	8.8	23.5	34.7	43.8	41.8	56.2	24497	29108	.75	58.16	4.24	1.48	11.87	HVB-C
4-35- 9-22W4M	BR-G	191.4	191.7	CORE			14.1	24.3	32.2	40.9	43.5	59.1	23632	26228	.70	57.90	4.00			SUB-A
4-35- 9-22W4M	BR-G	191.7	191.8	CORE	2.6	10.4	8.8	40.9	27.6		31.5		18073		.77					INSF
4-35- 9-22W4M	BR-G	191.8	192.0	CORE	2.0	13.4	9.9	75.4	17.1		7.5		6078		.51					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL VALUE DRY	CAL VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-35- 9-22W4M	BR-G	192.9	193.3	CORE	2.6	10.5	8.5	24.0	36.7	46.7	39.3	53.3	24030	28882	1.19	58.12	4.33	1.38	10.95	HVB-C
5-22-11- 5W4M	BR-G	69.6	70.7	CUTT	6.2			11.4	40.1		48.5		24651		.75					INSF
16- 9-11- 6W4M	BR-G	51.2	53.3	CUTT	7.8			6.9	42.3		50.8		24639		.33					INSF
16- 9-11- 6W4M	BR-G	51.2	53.3	CUTT			26.9	12.1	36.1	40.3	51.8	59.7	25284	20429	.50	65.70	3.90			SUB-C
1-17-11-21W4M	BR-G	134.4	134.4	CUTT	2.3			48.8	24.7		26.5		14517		.54					INSF
1-17-11-21W4M	BR-G	134.4	134.4	CUTT			14.0	60.0	20.2		19.8		11188		.40	29.40	2.30			INSF
1-27-13- 8W4M	BR-G	95.4	96.0	CUTT	4.9			18.3	36.2		45.5		22872		.87					INSF
1-27-14-20W4M	BR-G	107.3	109.1	CORE	5.3	13.6	12.3	22.3	37.2	46.5	40.5	53.5	23867	26558	.83	58.62	4.24	1.51	12.47	SUB-A
1-27-14-20W4M	BR-G	107.9	110.9	CORE	5.5	16.3	12.8	23.5	36.5	46.3	40.0	53.8	22923	25688	.76					SUB-A
1-22-15-13W4M	BR-G	68.2	69.8	CUTT	4.8			16.4	35.5		48.1		22644		.75					INSF
13-24-15-14W4M	BR-G	75.3	75.3	CUTT	3.7			16.4	35.2		48.4		23167		.44					INSF
13-24-15-14W4M	BR-G	93.2	93.2	CUTT	3.1			7.6	40.3		52.1		25977		.72					INSF
13-24-15-14W4M	BR-G	93.2	93.2	CUTT			23.6	10.3	35.2	38.6	54.5	61.4	26470	22102	.60	67.30	4.00			SUB-B
13-23-15-21W4M	BR-G	250.0	250.0	CUTT	3.3			15.3	36.8		47.9		25188		.61					INSF
13-23-15-21W4M	BR-G	250.0	250.0	CUTT			16.7	20.8	34.1	41.7	45.1	58.3	23725	24318	.60	59.60	4.00			SUB-B
14-21-15-22W4M	HC-F	33.2	33.9	CORE	4.7	15.4	12.5	28.0	34.6		37.4		19862		.41					INSF
14-21-15-22W4M	HC-F	36.5	38.1	CUTT	5.1			12.1	37.9		50.0		25746		.54					INSF
14-21-15-22W4M	HC-F	55.1	55.1	CUTT	4.2			12.2	36.7		51.1		26030		.63					INSF
14-21-15-22W4M	HC-F	184.4	184.4	CUTT	3.1			51.4	23.9		24.7		13416		.41					INSF
14-21-15-22W4M	HC-F	184.4	184.5	CORE	3.7	11.1	11.6	42.5	29.1		28.4		16973		.45					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL MATTER DRY	VL MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT ANALYSIS (DRY) S	C	H	N	O	COAL RANK
14-21-15-22W4M	HC-F	184.5	184.7	CORE	2.6	8.8	7.7	73.6	14.5		11.9		6706		.20					INSF
14-21-15-22W4M	HC-F	184.7	185.0	CORE	3.1	10.4	9.2	62.5	21.8		15.7		10311		.24					INSF
14-21-15-22W4M	HC-F	185.0	185.3	CORE	4.7	13.5	11.1	52.3	23.4		24.3		14079		.37	34.87	2.75	.89	8.85	INSF
14-21-15-22W4M	HC-F	185.3	185.6	CORE	3.3	16.0	11.6	31.7	32.6		35.7		20257		.47					INSF
14-21-15-22W4M	HC-F	185.6	185.9	CORE	5.5	19.2	12.3	24.4	34.8	44.5	40.8	55.5	22644	25835	.39					SUB-A
14-21-15-22W4M	HC-F	185.9	186.0	CORE	2.2	22.2	6.2	62.4	14.9		22.7		11500		.99					INSF
16-20-16-11W4M	BR-G	94.8	94.8	CUTT	7.6			9.4	42.8		47.8		24135		.56					INSF
16-22-16-20W4M	BR-G	202.7	203.2	CORE	5.2	14.9	12.0	22.8	37.4	47.1	39.8	52.9	23632	26568	.69					SUB-A
16-22-16-20W4M	BR-G	204.2	204.5	CORE	4.8	22.3	12.0	18.8	36.0	43.2	45.2	56.8	24688	26470	.62					SUB-A
16-22-16-20W4M	BR-G	204.5	204.8	CORE	3.2	18.0	12.0	20.2	37.3	45.6	42.5	54.5	24449	26640	.54					SUB-A
16-22-16-20W4M	BR-G	213.2	213.4	CORE	4.8	15.8	15.6	10.0	38.5	42.2	51.5	57.9	27670	25712	.68	68.46	4.58	1.67	14.66	SUB-A
16-22-16-20W4M	BR-G	213.4	214.6	CUTT	3.2			19.3	37.1		43.6		24049		.66					INSF
16-22-16-20W4M	BR-G	213.4	213.6	CORE	3.1	13.9	12.1	34.1	29.2		36.7		19243		.69					INSF
13-15-17-19W4M	BR-G	149.0	149.3	CUTT	4.1			23.0	34.2		42.8		22955		.51					INSF
1-10-17-21W4M	HC-F	46.9	57.0	CUTT	3.4			10.1	36.9		53.0		26816		.63					INSF
1-21-17-22W4M	HC-F	110.6	110.6	CUTT	4.1			16.2	36.0		47.8		24784		.58					INSF
1-21-17-22W4M	HC-F	131.7	131.7	CUTT	4.5			5.7	38.0		56.3		27703		.49					INSF
13-21-18-20W4M	HC-F	28.9	30.1	CUTT	5.1			6.2	39.2		54.6		26679		.77					INSF
13-21-18-20W4M	HC-F	138.7	140.2	CUTT	4.5			20.7	37.4		41.9		23618		2.25					INSF
13-21-18-20W4M	HC-F	138.7	140.2	CUTT			17.2	29.1	31.4		39.5		20934		2.80	51.70	3.60			INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-18-23W4M	HC-F	267.3	271.3	CUTT	3.0			15.0	35.7		49.3		24974		.35					INSF
1-20-19-21W4M	HC-F	41.1	41.1	CUTT	4.5			17.8	36.3		45.9		22946		.55					INSF
1-20-19-21W4M	HC-F	57.6	57.9	CORE	4.1	15.3	13.3	16.4	38.7	45.4	44.9	54.6	24984	25600	.56	62.07	4.42	1.40	15.15	SUB-A
1-20-19-21W4M	HC-F	57.9	57.9	CUTT	3.8			7.9	39.4		52.7		27889		.77					INSF
1-20-19-21W4M	HC-F	57.9	58.2	CORE	6.1	16.9	14.6	5.9	40.5	42.7	53.6	57.3	28056	25346	.63					SUB-A
1-20-19-21W4M	HC-F	57.9	58.2	CORE	6.1	16.9	14.6	3.3	40.5	41.6	56.2	58.4	28056	24718	.63					SUB-A
16-21-19-22W4M	HC-F	181.4	181.4	CUTT	4.7			9.9	37.3		52.8		26128		.37					INSF
16-16-20-20W4M	HC-F	30.1	30.4	CUTT	3.3			42.5	26.3		31.2		15589		.51					INSF
16-16-20-20W4M	HC-F	76.2	80.4	CUTT	3.5			26.1	34.3		39.6		20501		.45					INSF
16-16-20-20W4M	HC-F	76.2	80.4	CUTT			16.8	32.2	29.7		38.3		19213		.30	49.20	3.30			INSF
13-11-20-21W4M	HC-F	44.8	45.7	CUTT	6.2			8.9	38.7		52.4		25565		.52					INSF
4-27-20-22W4M	HC-F	79.2	79.2	CUTT	3.4			18.0	34.9		47.1		23916		.54					INSF
4-27-20-22W4M	HC-F	189.0	189.0	CUTT	2.3			42.8	26.3		30.9		15935		1.58					INSF
4-27-20-22W4M	HC-F	198.1	198.1	CUTT	3.8			26.2	34.6		39.2		21495		.53					INSF
4-27-20-22W4M	HC-F	198.1	198.1	CUTT			18.5	38.0	28.4		33.6		17817		.30	45.10	3.10			INSF
4-27-20-22W4M	HC-F	211.8	211.8	CUTT	4.4			9.8	38.1		52.1		25637							INSF
16-22-22-21W4M	HC-F	168.9	170.1	CUTT	5.4			23.1	32.9		44.0		22046		.52					INSF
16-22-22-21W4M	HC-F	176.5	176.8	CUTT	3.9			38.0	28.0		34.0		16643		.30					INSF
16-10-22-22W4M	HC-F	179.8	179.8	CUTT	2.7			7.0	39.5		53.5		26509		.54					INSF
16-20-23-20W4M	HC-F	91.4	92.3	CUTT	3.1			26.6	31.5		41.9		20555		.43					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL MATTER DRY	VL MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL VALUE DRY	CAL VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-20-23-20W4M	HC-F	93.5	94.2	CUTT	3.9			7.4	40.3		52.3		26388		.51					INSF
16-20-23-20W4M	HC-F	93.5	94.2	CUTT			20.4	10.6	36.0	39.6	53.4	60.4	26074	22839	.60	66.30	4.20			SUB-B
16-20-23-20W4M	HC-F	94.0	94.2	CORE	5.2	18.5	16.7	6.0	38.9	41.0	55.1	59.0	28305	24932	.73					SUB-A
16-20-23-20W4M	HC-F	94.2	94.5	CORE	4.0	18.8	17.5	4.4	42.6	44.3	53.0	55.7	28603	24567	.51					SUB-A
16-20-23-20W4M	HC-F	97.5	98.4	CUTT	2.8			29.2	36.2		34.6		19087		.78					INSF
16-20-23-20W4M	HC-F	97.5	97.8	CORE	4.2	21.6	17.5	4.7	39.8	41.5	55.5	58.5	28393	24453	.51					SUB-A
16-20-23-20W4M	HC-F	97.8	98.1	CORE	4.2	17.4	15.9	15.2	38.2	44.2	46.6	55.8	25156	24551	.45	62.91	4.24	1.29	15.87	SUB-A
16-20-23-20W4M	HC-F	97.8	98.1	CORE	3.8	17.1	15.0	18.9	36.2	43.5	44.9	56.5	23700	24379	.47	59.37	4.12	1.29	15.79	SUB-B
16-20-23-20W4M	HC-F	97.8	98.1	CORE			16.6	21.1	33.3	40.9	45.6	59.1	22469	23137	.40	57.50	3.90			SUB-B
16-20-23-20W4M	HC-F	98.1	98.5	CORE	4.0	19.8	17.3	6.9	38.1	40.5	55.0	59.5	27714	24430	.58					SUB-A
16-20-23-20W4M	HC-F	98.1	98.4	CORE	.5	12.8		97.1												INSF
16-20-23-20W4M	HC-F	98.5	98.6	CORE	.5	10.4		95.3												INSF
16-20-23-20W4M	HC-F	98.6	98.9	CORE	4.2	18.8	14.8	21.6	36.7	45.5	41.7	54.5	23144	24621	.66					SUB-A
16-20-23-20W4M	HC-F	98.6	98.9	CORE	4.4	16.9	14.6	23.1	37.7	47.7	39.2	52.3	22895	24853	.62					SUB-A
16-20-23-20W4M	HC-F	98.6	98.9	CORE			19.4	20.3	33.8	41.1	45.9	58.9	23074	22592	.60	58.10	3.90			SUB-B
16-20-23-20W4M	HC-F	98.9	99.2	CORE	4.4	20.5	16.1	9.2	41.6	45.3	49.2	54.7	27191	24895	.62	67.15	4.49	1.49	17.03	SUB-A
16-20-23-20W4M	HC-F	99.2	99.3	CORE	3.7	15.9	14.2	24.0	35.3	45.0	40.7	55.1	21918	24190	.59					SUB-B
16-20-23-20W4M	HC-F	99.3	99.4	CORE	3.3	16.6	15.1	18.9	36.3	43.6	44.8	56.4	23507	24146	.57					SUB-B
16-20-23-20W4M	HC-F	99.4	99.7	CORE	4.3	19.8	16.0	5.2	38.4	40.1	56.4	59.9	28200	24872	.69					SUB-A
16-20-23-20W4M	HC-F	99.7	99.9	CORE	4.6	18.3	15.4	11.0	38.4	42.4	50.6	57.6	26937	25358	1.21					SUB-A

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL MATTER DRY	VL MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL VALUE DRY	CAL VALUE MMMT	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-20-23-20W4M	HC-F	99.9	100.1	CORE	1.5	13.0		92.5												INSF
16-21-23-21W4M	HC-F	114.3	115.2	CUTT	5.8			8.3	39.3		52.4		25774		.42					INSF
1-22-23-22W4M	HC-F	176.2	176.2	CUTT	4.2			29.0	31.6		39.4		20550		.49					INSF
1-22-23-22W4M	HC-F	188.7	188.7	CUTT	3.2			54.4	21.1		24.5		12158		.43					INSF
4-28-24-20W4M	HC-F	158.5	158.5	CUTT	6.4		16.2	37.4	28.3		34.3		17915		.98					INSF
14- 7-27-18W4M	HC-F	120.9	120.9	CORE	4.6		18.9	7.3	36.8	39.2	55.9	60.8	26696	23132	.64	68.88	4.61	1.49	17.08	SUB-B
14- 7-27-18W4M	HC-F	124.2	124.2	CORE	4.9		16.9	5.4	38.1	39.9	56.5	60.1	28093	24542	.63	71.78	4.80	1.49	15.91	SUB-A
14- 7-27-18W4M	HC-F	125.1	125.1	CORE	5.0		17.4	11.2	35.6	39.4	53.2	60.7	25616	23514	.68	66.56	4.40	1.38	15.81	SUB-B
14- 7-27-18W4M	HC-F	128.2	128.2	CORE	4.3		16.8	10.3	36.1	39.6	53.6	60.5	26233	24060	.78	67.27	4.68	1.44	15.56	SUB-B
14- 7-27-18W4M	HC-F	128.8	128.8	CORE	4.8		17.2	9.0	34.9	37.7	56.1	62.3	25644	23097	.80	68.21	4.28	1.09	16.62	SUB-B
14- 7-27-18W4M	HC-F	129.5	129.5	CORE	3.4		13.4	45.7	24.6		29.7		13984		.60	35.69	2.96	.84	14.21	INSF
15-33-27-18W4M	HC-F	70.3	70.3	CORE	5.7		19.6	6.5	38.2	40.4	55.3	59.6	27305	23269	.60	69.92	4.30	1.35	17.32	SUB-B
5-14-27-20W4M	HC-F	178.3	178.3	CUTT	6.4		14.4	38.1	24.8		37.1		17840		1.09					INSF
5-14-27-20W4M	HC-F	196.6	196.6	CUTT	7.2		14.1	28.5	29.9		41.6		20855		1.14					INSF
16- 9-28-18W4M	HC-F	64.0	64.0	CUTT	7.3		17.4	9.8	41.0	44.9	49.3	55.2	25849	23390	.60					SUB-B
1-24-28-19W4M	HC-F	74.8	74.8	CORE	3.9		16.1	35.3	28.8		35.9		19015		.52	47.80	3.37	1.18	11.89	INSF
1-24-28-19W4M	HC-F	88.7	88.7	CORE	5.4		18.7	7.3	39.9	42.6	52.8	57.4	27970	24304	.66					SUB-B
1-24-28-19W4M	HC-F	200.0	200.0	CORE	4.3		16.1	17.8	40.4	48.1	41.8	51.9	25393	25416	.70	62.81	4.88	1.55	12.27	SUB-A
16-21-28-20W4M	HC-F	182.3	184.4	CUTT	5.6		13.4	39.3	25.6		35.1		17794		.86					INSF
16-21-28-20W4M	HC-F	182.3	184.4	CUTT			16.1	12.2	37.5	42.0	50.3	58.0	26377	24888	.50					SUB-A

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-29-29-18W4M	HC-F	87.2	87.3	CORE	2.2	14.0		94.6	5.3		.1				.12					INSF
1-29-29-18W4M	HC-F	87.3	87.6	CORE	9.0	16.4	17.3	26.4	32.6		41.1		22030		.33					INSF
1-29-29-18W4M	HC-F	87.5	87.7	CORE	6.5	19.4	20.0	77.2	12.7		10.2				.12					INSF
1-29-29-18W4M	HC-F	87.7	88.0	CORE	7.8	17.8	16.4	37.7	27.9		34.4		18589		.27					INSF
1-29-29-18W4M	HC-F	88.0	88.3	CORE	9.5	21.2	19.1	8.0	38.2	41.0	53.9	59.0	27870	24232	.33					SUB-B
1-29-29-18W4M	HC-F	88.0	88.3	CORE			20.2	8.9	37.5	40.7	53.6	59.4	26656	23041	.30					SUB-B
1-29-29-18W4M	HC-F	88.3	88.6	CORE	9.7	17.6	18.6	12.3	36.6	41.0	51.2	59.1	26668	24330	.30					SUB-B
1-29-29-18W4M	HC-F	88.3	88.6	CORE				14.2							.30	64.00	4.10			INSF
1-29-29-18W4M	HC-F	88.6	88.9	CORE	9.0	18.3	17.9	14.0	36.9	42.2	49.1	57.9	25798	24188	.29					SUB-B
1-29-29-18W4M	HC-F	88.9	89.0	CORE	9.0	18.3	17.6	9.1	38.2	41.5	52.8	58.5	27691	24821	.38					SUB-A
1-29-29-18W4M	HC-F	89.0	89.2	CORE	3.8	16.8	12.7	85.8	11.1		3.2				.15					INSF
16- 6-29-19W4M	HC-F	104.5	104.5	CORE	5.5		19.2	5.3	36.8	38.5	57.9	61.5	28726	24342	.60	71.49	4.55	1.74	16.32	SUB-B
16- 6-29-19W4M	HC-F	119.4	119.4	CORE	5.2		18.7	6.2	39.0	41.2	54.8	58.8	26858	23097	.55	71.27	4.80	1.62	15.53	SUB-B
13- 1-30-17W4M	SC-M	111.2	111.2	CUTT	7.9		19.8	18.5	38.0	45.6	43.5	54.4	23718	22655	.68					SUB-B
16-21-30-18W4M	HC-F	153.6	153.6	CUTT	6.9		16.7	41.2	27.8		31.0		16761		.87					INSF
16-20-30-19W4M	HC-F	144.8	144.8	CUTT	5.7		15.6	40.6	27.8		31.5		16750		.83					INSF
1-27-31-17W4M	HC-F	72.5	73.4	CUTT	7.3		16.6	40.1	32.4		27.5		16540		.60					INSF
1-27-31-17W4M	HC-F	72.5	73.4	CUTT			20.5	35.4	32.0		32.6		17910		.30					INSF
1-27-31-17W4M	HC-F	147.8	147.8	CUTT	6.4		16.6	40.2	25.5		34.2		16805		.93					INSF
8-23-31-21W4M	HC-F	199.4	199.4	CORE	3.8		18.4	40.1	27.9		32.0		17250		.31					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL MATTER DRY	VL MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
8-23-31-21W4M	HC-F	200.8	200.8	CORE	3.9		17.2	46.3	25.4		28.3		15370		.27	39.05	2.95	.87	10.59	INSF
8-23-31-21W4M	HC-F	202.2	202.2	CORE	4.5		18.0	10.1	38.7		51.2		27170							INSF
8-23-31-21W4M	HC-F	202.6	202.6	CORE	4.6		18.6	10.3	38.2	42.0	51.5	58.1	27228	24376	.61	67.94	4.44	1.40	15.36	SUB-B
8-23-31-21W4M	HC-F	216.7	216.7	CORE	4.5		17.8	11.2	37.7	41.8	51.1	58.2	27226	24856	.49	67.29	4.62	1.61	14.74	SUB-A
3- 5-31-24W4M	SC-M	93.0	93.9	CUTT	3.2			15.0	35.6		49.4		25723		1.19					INSF
3- 5-31-24W4M	HC-F	198.0	200.0	CUTT	2.1			26.8	32.3		40.9		22385		.73					INSF
3- 5-31-24W4M	HC-F	203.0	204.0	CUTT	2.5			25.7	34.3		40.0		22695		.62					INSF
4-26-31-25W4M	UNKN	100.3	101.6	CUTT	4.5			13.6	36.9		49.5		25633		.50					INSF
16-22-32-17W4M	HC-F	112.7	112.8	CORE	5.2	19.9		88.7	10.2		1.1				1.98					INSF
16-22-32-17W4M	HC-F	112.8	113.0	CORE	11.4	21.7	19.5	9.5	45.5	49.5	45.0	50.5	27372	24053	2.07					SUB-B
16-22-32-17W4M	HC-F	113.0	113.3	CORE	12.6	22.1	19.7	14.0	37.6	42.9	48.4	57.1	25453	23272	.63					SUB-B
16-22-32-17W4M	HC-F	113.3	113.6	CORE	10.7	21.3	19.6	20.5	37.4	45.8	42.1	54.2	23181	22681	.55					SUB-B
16-22-32-17W4M	HC-F	113.6	113.9	CORE	12.0	21.5	20.5	7.3	39.6	42.2	53.2	57.8	28403	24080	.66					SUB-B
16-22-32-17W4M	HC-F	113.9	114.1	CORE	7.3	20.0	16.9	68.4	17.9		13.7		7708		.37					INSF
16-22-32-17W4M	HC-F	120.4	120.5	CORE	2.9	12.6		93.5	5.6		.9				.15					INSF
16-22-32-17W4M	HC-F	120.5	120.8	CORE	13.5	22.7	21.5	9.5	40.6	44.4	49.8	55.7	26689	22797	.59					SUB-B
16-22-32-17W4M	HC-F	120.8	121.1	CORE	13.0	24.7	21.4	5.2	39.0	40.8	55.8	59.2	28156	23155	.55					SUB-B
16-22-32-17W4M	HC-F	121.1	121.4	CORE	12.9	23.1	20.9	4.7	39.3	40.9	56.0	59.1	28398	23414	.57					SUB-B
16-22-32-17W4M	HC-F	121.4	121.7	CORE	13.3	24.5	21.6	5.6	41.7	43.8	52.8	56.2	28263	23253	.46					SUB-B
16-22-32-17W4M	HC-F	121.7	122.1	CORE	12.6	22.4	19.6	5.5	39.9	41.9	54.7	58.2	28147	23758	.42					SUB-B

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	S	ULT-ANALYSIS (DRY) C	H	N	O	COAL RANK
16-22-32-17W4M	HC-F	122.1	122.4	CORE	11.0	20.3	19.3	15.1	37.5	43.2	47.5	56.8	25202	23411	.52					SUB-B
16-22-32-17W4M	HC-F	122.4	122.7	CORE	12.8	21.4	20.1	7.1	40.7	43.4	52.2	56.6	27533	23437	.54					SUB-B
16-22-32-17W4M	HC-F	122.7	123.0	CORE	12.1	21.4	19.9	8.9	39.4	42.8	51.7	57.3	26691	23169	.58					SUB-B
16-22-32-17W4M	HC-F	123.0	123.2	CORE	9.3	24.7	18.7	62.3	19.1		18.5		9162		.28					INSF
16-22-32-17W4M	HC-F	123.2	123.4	CORE	13.0	21.6	20.0	10.1	38.7	42.5	51.2	57.5	26737	23441	.60					SUB-B
16-22-32-17W4M	HC-F	123.4	123.4	CUTT	8.0		20.0	22.3	36.7	45.7	41.0	54.3	21832	21636	1.62					SUB-C
8-28-32-19W4M	HC-F	17.9	18.9	CUTT	3.3			9.1	39.4		51.5		26495		.54					INSF
8-28-32-19W4M	HC-F	144.0	145.0	CUTT	3.7			28.5	33.5		38.0		20783		.60					INSF
8-28-32-19W4M	HC-F	164.0	166.0	CUTT	4.4			9.5	36.9		53.6		26188		.69					INSF
8-28-32-19W4M	HC-F	198.0	199.0	CUTT	4.2			19.8	37.0		43.2		22527		.55					INSF
16-22-32-23W4M	HC-F	102.1	102.1	CORE	3.1			17.0	40.6		42.4		25526		.46	62.69	4.65	1.32	13.88	INSF
16-22-32-23W4M	HC-F	103.6	103.6	CORE	3.5			14.0	41.5		44.5		26486		.52	65.41	4.51	1.33	14.26	INSF
16-22-32-23W4M	SC-M	105.0	106.0	CUTT	4.2			24.0	34.6		41.4		22632		.45	56.29	3.83	1.10	14.33	INSF
16-22-32-23W4M	HC-F	110.3	110.3	CORE	3.2			8.3	41.8		49.9		27544		.61	69.54	4.44	1.29	15.87	INSF
16-22-32-23W4M	HC-F	111.0	112.1	CUTT	3.8			24.2	34.6		41.2		22625		.46	56.68	3.86	.98	13.83	INSF
15-20-32-24W4M	SC-M	52.9	53.9	CUTT	3.9			14.3	35.1		50.6		25849		.31					INSF
16- 8-32-25W4M	SC-M	117.3	118.9	CUTT	6.4			24.3					23237		.90					INSF
16- 8-32-25W4M	SC-M	121.9	126.5	CUTT	6.5			16.9					25705		1.79					INSF
1-29-33-15W4M	HC-F	27.4	27.4	CUTT	7.6		21.8	46.0	26.9		27.1		14819		.82					INSF
4-27-33-17W4M	HC-F	100.6	102.1	CUTT	9.1		18.4	31.2	32.9		35.9		18855		1.26					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-14-33-18W4M	HC-F	129.5	129.5	CUTT	8.4		16.7	16.8	35.7	41.7	47.5	58.3	22827	22406	1.39					SUB-B
13-21-33-23W4M	SC-M	20.0	22.9	CUTT	4.5			11.5	36.5		52.0		26388		.54	66.21	4.06	1.12	16.57	INSF
1-18-33-26W4M	SC-M	170.7	175.6	CUTT	6.0			20.9					24088		.60					INSF
13-10-33-27W4M	SC-M	253.0	257.6	CUTT	5.6			26.1	28.1		45.8		22806		.84					INSF
16-21-34-17W4M	HC-F	131.0	133.2	CUTT			20.4	26.6	33.0		40.4		20794		.30					INSF
16-21-34-17W4M	HC-F	131.0	133.2	CUTT	9.3		20.3	31.9	30.9		37.2		18164		.69					INSF
16- 7-34-25W4M	SC-M	181.0	187.0	CUTT	3.6			15.2	36.4		48.4		25223		.31					INSF
16- 7-34-25W4M	HC-F	272.0	273.0	CUTT	2.3			34.3	31.1		34.6		19845		.44					INSF
16- 7-34-25W4M	HC-F	278.0	279.0	CUTT	2.6			22.1	37.6		40.3		23939		.50	58.52	4.22	1.08	13.59	INSF
13- 9-34-26W4M	SC-M	274.6	276.8	CUTT	5.1			23.5	29.1		47.4		23597		.37					INSF
1-21-35-16W4M	HC-F	60.3	60.5	CORE	8.0	31.5	20.7	66.9	18.7		14.5		8253		.29					INSF
1-21-35-16W4M	HC-F	60.5	60.8	CORE	12.0	20.9	20.5	16.2	42.7	50.1	41.1	49.9	23630	21816	.39					SUB-C
1-21-35-16W4M	HC-F	60.5	60.8	CORE			22.9	19.7	36.2	43.9	44.1	56.1	22725	20955	.30					SUB-C
1-21-35-16W4M	HC-F	60.8	61.1	CORE	14.2	23.7	21.5	18.1	42.5	51.0	39.4	49.0	22876	21201	.40					SUB-C
1-21-35-16W4M	HC-F	60.9	62.5	CUTT	8.6		22.5	31.7	36.5		31.8		18322		.96					INSF
1-21-35-16W4M	HC-F	61.1	61.4	CORE	12.6	22.1	21.1	7.7	46.4	49.9	46.0	50.1	26067	22006	.32					SUB-C
1-21-35-16W4M	HC-F	61.1	61.4	CORE			23.5	10.4							.30	66.30	4.00			INSF
1-21-35-16W4M	HC-F	61.4	61.7	CORE	13.7	23.9	22.6	5.2	45.6	47.8	49.3	52.2	26640	21548	.28					SUB-C
1-21-35-16W4M	HC-F	62.5	62.7	CORE	11.3	24.4	24.1	19.0	53.1	64.8	28.0	35.2	22488	20204	.37					SUB-C
1-21-35-16W4M	HC-F	62.5	62.5	CUTT	8.7		19.2	28.4	35.4		36.2		19415		.57					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-21-35-16W4M	HC-F	62.7	62.8	CORE	4.9	22.2	14.3	81.0	12.4		6.5				.23					INSF
1-21-35-16W4M	HC-F	149.8	149.9	CORE	4.1	17.7		88.3	8.2		3.5				.20					INSF
1-21-35-16W4M	HC-F	149.9	150.2	CORE	13.2	26.0	21.8	23.4	39.9	50.8	36.8	49.3	21343	20785	.44					SUB-C
1-21-35-16W4M	HC-F	150.2	150.6	CORE	13.5	24.9	21.7	20.6	35.7	43.8	43.7	56.2	22127	20976	.49					SUB-C
1-21-35-16W4M	HC-F	150.6	150.8	CORE	5.2	21.6	15.2	74.6	14.0		11.4		5755		.23					INSF
1-21-35-16W4M	HC-F	160.0	163.1	CUTT	8.0		20.0	36.6	38.3		25.1		17347		.90					INSF
1-28-35-17W4M	HC-F	112.8	112.8	CUTT	9.7		18.2	24.5	38.0	48.9	37.4	51.1	21064	21982	1.00					SUB-C
16-23-35-22W4M	SC-M	66.3	66.9	CUTT	5.6			14.3	34.2		51.5		24356		.59					INSF
13-14-35-24W4M	HC-F	169.0	170.0	CUTT	3.5			50.6	25.2		24.2		13379		.41	35.27	2.71	.68	10.36	INSF
13-14-35-24W4M	HC-F	171.0	172.0	CUTT	3.6			26.7	35.0		37.3		20978		.50					INSF
13-14-35-24W4M	HC-F	185.0	186.0	CUTT	3.8			19.4	34.8		45.8		23916		.47	60.61	4.05	1.08	14.30	INSF
12-15-35-25W4M	SC-M	193.5	198.1	CUTT											.38					INSF
8-27-35-26W4M	SC-M	218.9	226.2	CUTT	6.7			16.6	32.7		50.7		25349		.48					INSF
13-22-36-16W4M	HC-F	51.8	53.3	CUTT	9.9		20.6	20.5	37.9	46.4	41.6	53.6	21981	21176	1.11					SUB-C
4-25-36-17W4M	HC-F	100.6	102.1	CUTT	9.2		20.5	25.2	35.5		39.3		21227		1.28					INSF
2- 3-36-21W4M	SC-M	58.9	60.0	CUTT	5.5			18.0	35.5		46.5		23690		.85					INSF
2- 3-36-21W4M	SC-M	60.0	62.9	CUTT	5.2			12.2	37.0		50.8		25358		.38	65.04	3.89	.97	17.49	INSF
2- 3-36-21W4M	SC-M	76.0	78.0	CUTT	4.4			32.2	33.3		34.5		19424		.59					INSF
2- 3-36-21W4M	HC-F	122.0	123.0	CUTT	4.7			35.7	30.5		33.8		18154		.57	46.55	3.26	.86	13.10	INSF
4-14-36-22W4M	SC-M	37.9	40.0	CUTT	4.4			12.7	37.0		50.3		25795		.38					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-14-36-22W4M	SC-M	40.0	41.0	CUTT	4.1			23.6	33.1		43.3		22692		.44					INSF
4-14-36-22W4M	HC-F	115.0	116.0	CUTT	3.6			22.5	34.4		43.1		22772		.40	57.43	3.85	1.10	14.67	INSF
4-22-36-24W4M	SC-M	174.3	178.0	CUTT	7.3			39.7	33.2		27.1		17180		.30					INSF
15-22-36-25W4M	SC-M	168.4	168.7	CORE	3.2	10.9		92.9												INSF
15-22-36-25W4M	SC-M	168.7	169.2	CORE	8.5	19.0	15.1	25.7	29.5		44.8		22202		.55					INSF
15-22-36-25W4M	SC-M	171.5	172.1	CORE	8.3	19.4	13.2	17.0	33.0	38.7	50.0	61.3	23828	24604	.25					SUB-A
15-22-36-25W4M	SC-M	172.1	172.4	CORE	4.8	15.6		88.8												INSF
15-22-36-25W4M	SC-M	172.8	173.1	CORE	6.7	23.1		31.1	26.1		42.8		20159		.33					INSF
15-22-36-25W4M	SC-M	173.1	173.4	CORE	7.2	20.8	13.6	10.3	31.1	34.0	58.6	66.0	26889	25705	.34	69.55	3.95	1.15	14.72	SUB-A
15-22-36-25W4M	SC-M	173.4	173.7	CORE	6.6	17.6	12.3	19.5	30.9	37.1	49.6	62.9	24486	26351	.46					SUB-A
15-22-36-25W4M	SC-M	173.4	173.7	CORE			15.7	18.4	32.4	38.5	49.2	61.5	25028	25351	.40	62.20	3.80			SUB-A
15-22-36-25W4M	SC-M	173.7	174.0	CORE	5.5	19.2	14.6	68.3	15.5		15.2		8320		.22					INSF
2-28-36-26W4M	SC-M	240.8	248.1	CUTT	5.9			28.1	29.3		42.6		20904		.31					INSF
2-28-36-26W4M	SC-M	240.8	248.1	CUTT			14.8	14.2	31.0	35.2	54.8	64.8	25563	25025	.40	65.50	4.00			SUB-A
16- 9-37-16W4M	HC-F	114.3	115.8	CUTT	9.3		20.3	36.2	33.3		30.5		17378		1.00					INSF
4-26-37-17W4M	HC-F	83.8	86.2	CUTT	10.0		19.0	14.2	42.4	48.5	43.4	51.5	23865	22067	1.82					SUB-C
4-26-37-17W4M	HC-F	121.9	121.9	CUTT	10.2		18.9	17.4	44.4	52.8	38.2	47.2	22988	22009	1.34					SUB-C
4-26-37-17W4M	HC-F	121.9	121.9	CUTT			23.4	15.6	37.7	43.8	46.7	56.2	24004	21108	.50					SUB-C
1-28-37-18W4M	HC-F	170.7	170.7	CUTT	9.8		20.0	16.2	41.7	48.9	42.1	51.1	23983	22306	1.11					SUB-B
2- 5-37-21W4M	SC-M	65.0	68.9	CUTT	4.1			17.0	37.7		45.3		24169		.35					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
2- 5-37-21W4M	SC-M	67.0	67.0	CORE	3.8			15.3	36.4		48.3		25244		.75	63.70	4.04	.88	15.39	INSF
2- 5-37-21W4M	SC-M	67.6	67.6	CORE	3.6			13.3	40.6		46.1		25005		.44	66.00	3.49	1.05	15.76	INSF
2- 5-37-21W4M	SC-M	68.2	68.2	CORE	4.0			7.0	41.9		51.1		26996		.46	68.76	4.27	1.01	18.57	INSF
2- 5-37-21W4M	SC-M	68.5	68.5	CORE	3.9			11.1	36.3		52.6		26058		.36	66.92	4.00	.95	16.76	INSF
2- 5-37-21W4M	SC-M	68.9	68.9	CORE	4.4			7.2	40.3		52.5		27135		.46	69.74	4.38	.94	17.23	INSF
2- 5-37-21W4M	SC-M	80.0	82.0	CUTT	3.8			34.3	32.8		32.9		19083		.59					INSF
2- 5-37-21W4M	SC-M	80.3	80.3	CORE	3.5			36.6	34.4		29.0		18450		.53	46.95	3.40	.69	11.88	INSF
2- 5-37-21W4M	SC-M	81.4	84.4	CORE	4.2			9.1	42.3		48.6		27086		.50	68.64	4.83	1.13	15.79	INSF
2- 5-37-21W4M	HC-F	137.0	139.0	CUTT	3.5			15.8	39.2		45.0		24551		.37	61.68	4.24	1.04	16.92	INSF
2- 5-37-21W4M	HC-F	137.1	137.1	CORE	3.9			11.6	41.9		46.5		26281		.35	66.07	4.46	1.31	16.27	INSF
2- 5-37-21W4M	HC-F	147.2	147.2	CORE	3.9			8.1	36.5		55.4		27072		.44	68.64	4.49	1.25	17.08	INSF
2- 5-37-21W4M	HC-F	150.6	150.6	CORE	6.0			7.2	41.0		51.8		27544		.45	70.26	4.73	1.48	15.83	INSF
2- 5-37-21W4M	HC-F	151.0	152.0	CUTT	4.6			14.4	35.1		50.5		25312		.41	63.52	4.09	1.14	16.51	INSF
8-22-37-24W4M	SC-M	68.9	68.9	CUTT	3.7			24.7	32.9		42.4		21992		.53					INSF
8-22-37-24W4M	SC-M	70.0	72.9	CUTT	4.0			14.2	37.5		48.3		25060		.34					INSF
8-22-37-24W4M	HC-F	141.0	141.0	CUTT	3.9			31.4	31.1		37.5		19736		.48					INSF
8-22-37-24W4M	HC-F	157.0	159.0	CUTT	3.7			21.4	36.4		42.2		23448		.37	58.62	3.91	1.21	12.43	INSF
8-22-37-24W4M	HC-F	160.0	160.0	CUTT	3.1			35.1	30.7		34.2		18657		.38					INSF
4-13-37-27W4M	SC-M	227.1	229.2	CUTT	7.4			18.4	32.5		49.1		24374		.38					INSF
16-14-37-27W4M	SC-M	198.0	199.0	CUTT	3.0			15.6	33.6		50.8		25372		1.52					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-14-37-27W4M	SC-M	214.0	218.0	CUTT	2.4			19.1	35.1		45.8		24290		.31					INSF
16-14-37-27W4M	HC-F	300.0	302.0	CUTT	2.2			26.9	33.7		39.4		22409		.52	55.13	3.90	.98	12.58	INSF
16-14-37-27W4M	HC-F	319.0	320.0	CUTT	3.4			23.4	37.0		39.6		23414		.39	58.13	3.82	1.07	13.17	INSF
16-21-38-16W4M	HC-F	86.8	89.3	CUTT	9.4		20.4	24.5	34.4	44.0	41.1	56.0	21188	21364	.93					SUB-C
13-21-38-17W4M	HC-F	103.9	104.0	CORE	5.7	12.2		94.1	3.1		2.7				.21					INSF
13-21-38-17W4M	HC-F	104.0	104.2	CORE	8.4	15.1	15.0	66.7	14.1		19.2		7359		.29					INSF
13-21-38-17W4M	HC-F	104.2	104.5	CORE	17.1	26.1	22.6	17.3	28.9	33.7	53.9	66.3	24451	22118	.46					SUB-B
13-21-38-17W4M	HC-F	104.5	104.8	CORE	15.7	26.7	20.6	10.6	32.5	35.6	57.0	64.4	26112	22799	.51					SUB-B
13-21-38-17W4M	HC-F	104.5	104.8	CORE			23.3	17.1	34.7	40.8	48.2	59.2	23725	21197	.40					SUB-C
13-21-38-17W4M	HC-F	104.8	105.1	CORE	13.9	24.5	22.5	11.9	32.1	35.7	56.0	64.3	26054	22418	.44					SUB-B
13-21-38-17W4M	HC-F	104.8	105.1	CORE			22.8	14.8							.40	63.40	4.00			INSF
13-21-38-17W4M	HC-F	105.1	105.3	CORE	6.8	16.9	16.4	83.8	8.3		8.0				.15					INSF
13-21-38-17W4M	HC-F	106.5	106.6	CORE	6.5	18.8		89.9	10.1						.12					INSF
13-21-38-17W4M	HC-F	106.6	106.9	CORE	16.1	25.6	22.2	5.4	32.8	34.3	61.8	65.7	27354	22299	.56					SUB-B
13-21-38-17W4M	HC-F	106.9	107.2	CORE	14.5	24.2	23.8	22.9	27.2	33.5	50.0	66.5	22713	21313	.61					SUB-C
14-23-38-16W4M	HC-F	138.7	138.7	CUTT	8.7		17.7	36.7	34.2		29.1		17989		.71					INSF
1-33-38-23W4M	SC-M	31.0	32.9	CUTT	4.8			10.5	36.3		53.2		26086		.44					INSF
1-33-38-23W4M	SC-M	31.0	38.0	CUTT	4.2			16.4	34.3		49.3		24579		.53					INSF
1-33-38-23W4M	SC-M	33.9	36.0	CUTT	4.3			13.7	37.0		49.3		25309		.44					INSF
1-33-38-23W4M	SC-M	36.0	38.9	CUTT	3.8			21.6	36.2		42.2		22965		.45	58.24	3.76	.87	15.06	INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
3-28-38-24W4M	SC-M	59.4	59.4	CORE	4.5			18.2	38.6		43.2		23944		.55	62.15	3.50	.94	14.63	INSF
3-28-38-24W4M	SC-M	60.3	60.3	CORE	4.0			10.6	42.4		47.0		26640		.79	67.58	4.52	1.24	15.23	INSF
3-28-38-24W4M	SC-M	89.6	89.6	CORE	3.8			30.1	33.7		36.2		19634		.56	52.38	3.13	.79	13.02	INSF
3-28-38-24W4M	SC-M	90.0	93.9	CUTT	4.3			16.4	35.3		48.3		24535		.50					INSF
3-28-38-24W4M	SC-M	90.5	90.5	CORE	4.0			8.7	36.8		54.5		26702		.38	69.13	3.94	1.08	16.74	INSF
3-28-38-24W4M	SC-M	91.4	91.4	CORE	3.9			23.0	34.1		42.9		22497		.42	59.07	3.22	.76	13.57	INSF
3-28-38-24W4M	SC-M	94.5	94.5	CORE	2.1			71.0	17.3		11.7		9437		.32	19.46	1.84	.47	6.90	INSF
3-28-38-24W4M	SC-M	96.0	98.9	CUTT	4.0			20.2	36.6		43.2		23565		.61					INSF
13-23-38-25W4M	SC-M	123.7	126.5	CUTT	8.1			18.5	31.7		49.8		24167		.32					INSF
14-10-38-26W4M	SC-M	250.0	253.0	CUTT	6.0			15.1	36.2		48.7		25465		.27					INSF
15-14-38-27W4M	SC-M	207.3	213.4	CUTT	6.6		12.7	18.8	30.3	35.8	50.9	64.2	23509	24974	1.41					SUB-A
16-22-39-16W4M	HC-F	32.0	33.5	CUTT	8.5		19.7	25.5	34.4		40.1		20222		1.14					INSF
1-21-39-17W4M	HC-F	144.8	144.8	CUTT	7.1		19.1	44.0	24.5		31.5		15140		.56					INSF
13-22-39-18W4M	HC-F	132.6	134.1	CUTT	9.5		19.6	26.4	35.9		37.7		20641		.96					INSF
13-22-39-18W4M	HC-F	157.0	158.5	CUTT	9.5		21.8	34.5	29.3		36.1		18561		.93					INSF
14-10-39-23W4M	SC-M	40.0	41.9	CUTT	4.1			15.0	37.1		47.9		25291		.73					INSF
14-10-39-23W4M	HC-F	63.9	63.9	CUTT	3.4			39.0	29.6		31.4		16989		.46					INSF
4-29-39-24W4M	SC-M	89.0	92.6	CUTT	5.3			32.7	29.1		38.2		19906		.35					INSF
1-21-39-26W4M	SC-M	184.7	185.0	CORE	34.0	14.9		90.3												INSF
1-21-39-26W4M	SC-M	185.0	185.3	CORE	5.6	15.4	12.3	44.3	21.0		34.7		15877		.52					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-21-39-26W4M	SC-M	185.3	185.6	CORE	4.4	15.2	11.1	67.6	14.7		17.7		8185		.55					INSF
1-21-39-26W4M	SC-M	185.6	185.9	CORE	5.4	17.4	14.0	69.2	15.9		14.9		6904		.20					INSF
1-21-39-26W4M	SC-M	185.9	186.2	CORE	6.2	16.1	14.6	13.5	30.1	33.9	56.4	66.1	25944	25314	.45					SUB-A
1-21-39-26W4M	SC-M	186.2	186.5	CORE	6.7	16.5	14.3	9.4	33.4	36.3	57.2	63.7	27256	25588	.30	69.64	4.24	.81	15.56	SUB-A
1-21-39-26W4M	SC-M	186.5	186.8	CORE	6.5	17.9	13.8	9.2	33.5	36.3	57.3	63.7	27405	25842	.30					SUB-A
1-21-39-26W4M	SC-M	186.5	186.8	CORE			16.1	9.7	33.0	36.0	57.3	64.0	27447	25249	.20	69.80	4.00			SUB-A
1-21-39-26W4M	SC-M	186.8	187.1	CORE	6.2	18.3	12.3	23.3	32.6	41.0	44.1	59.0	22820	25686	.23					SUB-A
1-21-39-26W4M	SC-M	187.1	187.5	CORE	6.7	16.2	13.1	17.2	29.9	35.0	52.9	65.0	25079	25993	.32					SUB-A
1-21-39-26W4M	SC-M	187.5	187.8	CORE	3.9	15.3		83.2												INSF
1-21-39-26W4M	SC-M	187.8	188.1	CORE	7.2	23.7		91.9												INSF
1-21-39-26W4M	SC-M	188.1	188.4	CORE	6.1	18.2	11.9	58.1	17.9		24.0		11272		.19					INSF
1-21-39-26W4M	SC-M	188.4	188.7	CORE	7.0	20.0	16.7	46.8	29.0		24.2		14442		.25					INSF
1-21-39-26W4M	SC-M	188.7	189.0	CORE	6.1	15.6	12.7	16.5	30.0	34.8	53.5	65.2	24942	25793	.34					SUB-A
1-21-39-26W4M	SC-M	189.0	189.3	CORE	6.9	16.2	13.4	20.1	33.4	40.6	46.5	59.4	23951	25546	.25					SUB-A
1-21-39-26W4M	SC-M	189.3	189.6	CORE	6.4	20.5	16.7	35.5	24.1		40.4		18831		.19					INSF
1-21-39-26W4M	SC-M	189.6	189.9	CORE	7.0	22.0	14.1	31.6	29.1		39.3		20129		.22					INSF
1-21-39-26W4M	SC-M	189.9	190.2	CORE	3.8	13.3		83.5												INSF
13-23-40-16W4M	HC-F	28.9	30.4	CUTT	8.5		20.2	25.7	34.3		40.0		21113		.90					INSF
3-27-40-17W4M	HC-F	22.8	22.8	CUTT	9.2		20.3	11.8	37.4	41.6	50.8	58.4	24756	21971	1.05					SUB-C
3-27-40-17W4M	HC-F	97.5	102.1	CUTT	7.1		17.4	45.4	28.1		26.5		14640		1.05					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-22-40-18W4M	HC-F	169.2	169.2	CUTT	6.7		16.6	27.9	32.6		36.4		19876		1.23					INSF
1-16-40-23W4M	SC-M	72.0	72.9	CUTT	3.9			15.0	40.6		44.4		25072		.45					INSF
1-16-40-23W4M	HC-F	175.0	176.0	CUTT	3.9			9.5	38.9		51.6		26047		.63					INSF
2- 4-40-24W4M	SC-M	53.9	53.9	CUTT	4.3			16.2	37.4		46.4		24867		1.70	82.74	4.05	.96	14.40	INSF
2- 4-40-24W4M	SC-M	90.0	93.0	CUTT	3.8			12.2	36.6		51.2		25539		.40					INSF
2- 4-40-24W4M	SC-M	95.0	95.0	CUTT	3.8			15.5	37.9		46.6		24774		.38					INSF
2- 4-40-24W4M	SC-M	97.0	97.0	CUTT	3.4			23.4	32.2		44.4		21909		.62					INSF
5-16-40-25W4M	SC-M	181.4	181.4	CUTT	5.5			23.3	30.4		46.3		22369		.32					INSF
8-27-40-25W4M	SC-M	144.0	144.0	CUTT	4.1			11.6	34.6		53.8		26500		.54					INSF
8-27-40-25W4M	SC-M	149.0	149.0	CUTT	3.7			15.0	37.9		47.1		25737		.40					INSF
15-21-40-26W4M	SC-M	157.0	164.6	CUTT	4.8		11.7	26.7	29.1		44.2		22234		.36					INSF
15-21-40-26W4M	SC-M	157.0	164.6	CUTT			13.9	16.7	30.3	35.3	53.0	64.7	25307	25800	.40	63.20	3.80			SUB-A
1-29-40-27W4M	SC-M	251.5	259.1	CUTT	4.2		9.9	24.7	30.9	39.4	44.4	60.6	23207	27538	.38					HVB-C
1-28-41-17W4M	HC-F	82.3	82.3	CUTT	9.0		20.2	14.3	38.3	43.7	47.4	56.3	24190	22011	1.40					SUB-C
13-15-41-18W4M	HC-F	84.0	84.2	CORE	3.6	14.6	7.4	89.7	7.6		2.7				.06					INSF
13-15-41-18W4M	HC-F	84.2	84.5	CORE	12.3	23.5	20.6	21.5	40.7	50.7	37.8	49.3	23465	22851	.44					SUB-B
13-15-41-18W4M	HC-F	84.6	84.8	CORE	11.5	23.9	21.3	44.7	27.3		28.0		15863		.20					INSF
13-15-41-18W4M	HC-F	84.8	85.1	CORE	12.5	23.8	19.8	5.3	41.5	43.5	53.2	56.5	28084	23604	.51					SUB-B
13-15-41-18W4M	HC-F	84.8	85.1	CORE			22.6	6.3	39.5	41.8	54.2	58.2	27237	22253	.30					SUB-B
13-15-41-18W4M	HC-F	85.1	85.4	CORE	12.2	24.9	20.5	13.3	39.7	45.1	47.0	54.9	25672	23032	.21					SUB-B

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-15-41-18W4M	HC-F	85.1	85.4	CORE			23.5	12.0							.40	73.90	4.60			INSF
13-15-41-18W4M	HC-F	85.3	88.4	CUTT	8.8		18.4	29.1	30.4		40.4		19487		.64					INSF
13-15-41-18W4M	HC-F	85.4	85.8	CORE	10.5	18.9	16.1	38.5	28.6		32.9		17980		.31					INSF
13-15-41-18W4M	HC-F	86.0	86.4	CORE	13.0	25.7	21.4	7.6	42.2	45.3	50.2	54.7	27631	23218	.39					SUB-B
13-15-41-18W4M	HC-F	86.4	86.7	CORE	11.2	26.5	19.0	51.4	26.2		22.4		13572		.20					INSF
13-15-41-18W4M	HC-F	86.7	87.0	CORE	11.9	28.6	20.7	31.8	33.8		34.4		20034		.32					INSF
13-15-41-18W4M	HC-F	87.0	87.3	CORE	14.0	26.7	20.1	8.7	38.4	41.6	52.9	58.4	28063	24235	.42					SUB-B
13-15-41-18W4M	HC-F	87.3	87.6	CORE	13.0	23.1	21.8	17.1	37.8	44.7	45.1	55.3	25128	22960	.36					SUB-B
13-15-41-18W4M	HC-F	87.6	88.0	CORE	14.0	24.1	19.4	10.7	37.2	41.0	52.1	59.0	27172	24160	.45					SUB-B
13-15-41-18W4M	HC-F	88.0	88.1	CORE	5.6	21.5	14.1	77.4	13.9		8.7				.19					INSF
13-14-41-23W4M	UNKN	20.0	22.9	CUTT	5.9			5.3	38.8		55.9		27242		.72					INSF
13-14-41-23W4M	HC-F	75.0	76.0	CUTT	4.2			27.2	32.6		40.2		21176		.54	52.70	3.78	.73	15.05	INSF
4-28-41-27W4M	SC-M	245.4	253.0	CUTT	5.4		11.9	19.3	31.4	37.6	49.3	62.4	24586	26547	.51					SUB-A
4-27-42-17W4M	HC-F	25.9	28.9	CUTT	9.0		19.3	22.8	37.3	46.9	39.9	53.1	21439	21590	.71					SUB-C
4-27-42-17W4M	HC-F	64.0	65.5	CUTT	8.1		19.7	26.8	35.6		37.6		20446		1.33					INSF
16-22-42-18W4M	HC-F	65.5	65.5	CUTT	8.7		20.1	23.9	36.1	46.0	40.0	54.0	21285	21418	.83					SUB-C
16-15-42-19W4M	HC-F	178.3	181.4	CUTT	8.2		18.8	24.3	34.5	44.1	41.1	55.9	21315	22002	.80					SUB-C
4-30-42-23W4M	SC-M	53.9	53.9	CUTT	4.7			14.5	35.9		49.6		25037		.64					INSF
4-30-42-23W4M	SC-M	78.9	78.9	CUTT	6.0			22.6	36.5		40.9		22955		.65					INSF
4-30-42-23W4M	HC-F	120.0	120.0	CUTT	3.9			10.1	40.6		49.3		25651		.66	66.91	4.42	1.20	16.70	INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-30-42-23W4M	HC-F	124.0	126.0	CUTT	4.3			23.2	35.3		41.5		22541		.38					INSF
4-30-42-23W4M	HC-F	132.0	132.0	CUTT	4.0			15.2	38.5		46.3		24946		.48					INSF
4-30-42-23W4M	HC-F	247.0	249.0	CUTT	3.8			24.9	33.2		41.9		21802		.56					INSF
16-10-42-25W4M	SC-M	98.9	100.0	CUTT	3.8			24.9	34.8		40.3		22134		1.70					INSF
16-10-42-25W4M	SC-M	126.0	127.0	CUTT	4.0			18.7	32.4		48.9		23969		.53					INSF
16-10-42-25W4M	HC-F	180.0	181.0	CUTT	3.8			23.1	35.0		41.9		22027		.36	56.91	3.73	.68	15.26	INSF
16-10-42-25W4M	HC-F	184.0	185.0	CUTT	4.0			25.3	33.9		40.8		21539		.31					INSF
13-21-42-25W4M	SC-M	106.7	112.8	CUTT	5.7		14.8	22.6	32.7	40.7	44.7	59.3	23521	25314	.64					SUB-A
8-29-42-26W4M	SC-M	141.7	146.3	CUTT	5.1		13.4	31.1	28.2		40.7		20706		.48					INSF
6-22-43-18W4M	HC-F	56.4	57.0	CUTT	7.6		20.4	35.5	30.5		34.0		17813		.64					INSF
6-22-43-19W4M	HC-F	175.3	175.3	CUTT	8.6		19.0	17.8	35.4	42.0	46.8	58.0	22862	21930	.36					SUB-C
5-22-43-27W4M	SC-M	138.7	141.7	CUTT	5.8		13.3	18.2	33.3	39.5	48.5	60.5	24935	26077	.74					SUB-A
13-22-44-19W4M	HC-F	57.9	57.9	CUTT	10.6		21.2	15.5	37.5	43.5	46.9	56.5	24314	22071	.55					SUB-C
13-22-44-19W4M	HC-F	70.2	70.3	CORE	4.5	21.1		91.6	6.1		2.3				.16					INSF
13-22-44-19W4M	HC-F	70.3	70.7	CORE	12.2	21.3	20.8	14.3	36.9	42.2	48.8	57.8	25284	22825	.38					SUB-B
13-22-44-19W4M	HC-F	70.3	70.7	CORE			22.7	15.4	36.1	41.8	48.5	58.3	24400	21641	.40					SUB-C
13-22-44-19W4M	HC-F	70.7	71.0	CORE	11.6	26.4	21.6	39.9	26.3		33.8		16794		.35					INSF
13-22-44-19W4M	HC-F	71.0	71.3	CORE	13.2	25.8	22.6	21.9	37.0	46.1	41.1	53.9	22702	21509	.44					SUB-C
13-22-44-19W4M	HC-F	71.3	71.6	CORE	12.2	24.1	21.0	17.0	35.4	41.7	47.6	58.4	24656	22785	.41					SUB-B
13-22-44-19W4M	HC-F	71.6	71.7	CORE	12.6	23.5	22.0	7.5	37.4	39.9	55.1	60.1	27400	22816	.38					SUB-B

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-22-44-19W4M	HC-F	71.7	72.0	CORE	8.8	16.3	17.4	53.1	23.4		23.6		12235		32					INSF
13-22-44-19W4M	HC-F	72.0	72.4	CORE	12.6	21.2	21.0	14.5	38.2	43.8	47.3	56.2	25144	22674	.64					SUB-B
13-22-44-19W4M	HC-F	72.4	72.7	CORE	13.4	22.7	21.9	7.2	36.6	38.9	56.2	61.1	27261	22669	.61					SUB-B
13-22-44-19W4M	HC-F	72.4	72.7	CORE			23.4	7.4							.50	66.70	4.10			INSF
13-22-44-19W4M	HC-F	73.1	74.0	CUTT	10.4		19.9	24.9	34.6	44.4	40.5	55.6	21404	21848	.78					SUB-C
13-22-44-19W4M	HC-F	117.4	117.7	CORE	12.0	22.4	19.7	19.7	34.5	41.7	45.9	58.3	23120	22385	.41					SUB-B
13-22-44-19W4M	HC-F	117.7	118.0	CORE	12.7	19.0	21.0	11.2	38.9	43.2	49.9	56.8	26514	23162	.30					SUB-B
13-22-44-19W4M	HC-F	118.0	118.3	CORE	11.8	19.6	20.5	13.0	38.0	42.9	49.0	57.1	25723	23025	.48					SUB-B
13-22-44-19W4M	HC-F	118.3	118.6	CORE	12.8	21.0	22.8	9.5	38.1	41.5	52.5	58.5	26940	22576	.39					SUB-B
13-22-44-19W4M	HC-F	118.6	118.9	CORE	12.5	21.2	22.2	6.6	40.1	42.5	53.4	57.5	27440	22595	.34					SUB-B
13-22-44-19W4M	HC-F	118.9	119.2	CORE	13.4	22.3	22.7	6.6	38.4	40.7	55.0	59.3	27489	22488	.31					SUB-B
13-22-44-19W4M	HC-F	119.2	119.5	CORE	12.9	21.3	20.9	14.1	33.6	38.3	52.2	61.7	24918	22416	.18					SUB-B
13-22-44-19W4M	HC-F	119.5	119.8	CORE	14.0	23.4	21.4	6.0	36.1	38.1	57.9	62.0	27449	22739	.41					SUB-B
13-22-44-19W4M	HC-F	119.8	120.1	CORE	13.2	22.2	21.8	6.0	39.0	41.2	55.0	58.8	27435	22597	.33					SUB-B
13-22-44-19W4M	HC-F	120.1	120.4	CORE	13.1	22.7	21.0	6.0	39.1	41.9	54.3	58.1	27626	23002	.30					SUB-B
13-22-44-19W4M	HC-F	120.4	120.7	CORE	9.1	15.1	15.1	33.2	26.2		40.6		19094		.22					INSF
13-22-44-19W4M	HC-F	120.7	121.0	CORE	12.0	23.0	20.0	15.3	31.9	36.6	52.8	63.4	24677	22755	.62					SUB-B
13-22-44-19W4M	HC-F	121.0	121.1	CORE	8.4	18.9	16.5	58.4	20.4		21.2		9897		.48					INSF.
13-22-44-19W4M	HC-F	121.9	123.4	CUTT	9.6		19.4	25.7	32.9		41.4		21018		.52					INSF
16-22-44-20W4M	HC-F	182.9	182.9	CUTT	8.9		18.3	48.0	25.2		26.8		13993		.37					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL VALUE DRY	CAL VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
5-26-45-19W4M	HC-F	62.5	67.0	CUTT	12.7		20.1	29.2	29.8		41.0		20673		.85					INSF
8-24-45-28W4M	SC-M	121.9	123.4	CUTT	5.5		15.2	19.7	33.9	41.0	46.4	59.0	24195	25042	.54					SUB-A
8-24-45-28W4M	SC-M	121.9	123.4	CUTT			17.0	14.7	30.3	34.5	55.0	65.5	25144	24042	.40	63.80	3.70			SUB-B
13-22-46-19W4M	HC-F	100.6	102.4	CUTT	8.5		19.7	31.6	32.4		36.0		18706		.59					INSF
13-22-46-19W4M	HC-F	108.2	108.2	CUTT	10.5		18.8	26.3	35.2		38.5		21420		.83					INSF
16-16-46-20W4M	HC-F	105.1	105.1	CUTT	10.8		20.2	35.3	47.7		17.1		18164		.73					INSF
16-16-46-20W4M	HC-F	137.1	141.7	CUTT	12.8		19.8	22.9	38.7	48.8	38.4	51.2	22095	22102	.87					SUB-B
4-27-46-21W4M	HC-F	114.3	115.8	CUTT	9.0		19.5	30.9	31.4		37.6		19452		.48					INSF
4-27-46-21W4M	HC-F	152.4	152.4	CUTT	9.5		17.8	26.8	33.3		39.9		21569		.62					INSF
5-23-46-22W4M	HC-F	100.6	102.1	CUTT	8.7		18.6	25.8	32.2		42.0		22137		.51					INSF
1-18-46-27W4M	SC-M	135.6	137.1	CUTT	5.4		13.4	20.5	32.5	39.5	47.0	60.6	24258	26018	.82					SUB-A
1-18-46-27W4M	SC-M	181.4	182.9	CUTT	5.0		11.2	35.0	28.9		36.1		18927		.26					INSF
4-28-47-20W4M	HC-F	74.8	75.0	CORE	2.4	11.4		88.8	10.5		.7				.16					INSF
4-28-47-20W4M	HC-F	75.0	75.3	CORE	11.6	20.1	22.0	7.1	40.8	43.6	52.1	56.4	27140	22523	.09					SUB-B
4-28-47-20W4M	HC-F	75.3	75.6	CORE	11.7	19.7	22.1	10.5	41.4	45.8	48.1	54.2	25884	22120	.24					SUB-B
4-28-47-20W4M	HC-F	75.6	75.9	CORE	10.7	25.7	23.1	70.6	21.0		8.4		5627		.18					INSF
4-28-47-20W4M	HC-F	75.9	76.2	CORE	8.9	18.3	19.4	27.6	34.9		37.5		20548		.48					INSF
4-28-47-20W4M	HC-F	76.2	76.5	CORE	9.8	17.6	20.7	21.9	36.2	45.1	41.9	54.9	21985	21457	.40					SUB-C
4-28-47-20W4M	HC-F	76.7	76.8	CORE	4.1	13.1	13.9	76.4	17.2		6.4		4803		.30					INSF
4-28-47-20W4M	HC-F	77.2	77.4	CORE	3.8	15.7	10.4	76.4	18.9		4.7		4208		.06					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-28-47-20W4M	HC-F	77.4	77.7	CORE	11.2	19.3	19.8	14.0	37.3	42.5	48.7	57.5	25325	23116	.38					SUB-B
4-28-47-20W4M	HC-F	77.7	77.8	CORE	3.1	12.1		82.5	13.1		4.4		3289							INSF
4-28-47-20W4M	HC-F	78.4	78.6	CORE	2.4	14.1		92.4	7.6						.03					INSF
4-28-47-20W4M	HC-F	78.6	78.9	CORE	10.2	18.2	20.3	26.9	33.5		39.6		20583		.30					INSF
4-28-47-20W4M	HC-F	78.9	79.1	CORE	2.4	16.8		87.7	10.5		1.8				.09					INSF
4-28-47-20W4M	HC-F	86.8	88.4	CUTT	11.0		23.9	30.3	36.6		33.2		18822		1.00					INSF
4-28-47-20W4M	HC-F	114.8	115.0	CORE	4.9	13.2		93.6	6.3		.1				.27					INSF
4-28-47-20W4M	HC-F	115.0	115.3	CORE	10.7	19.7	21.1	8.1	39.9	42.9	52.1	57.1	26672	22597	.53					SUB-B
4-28-47-20W4M	HC-F	115.3	115.6	CORE	11.8	21.7	21.4	4.8	40.2	42.0	55.0	58.1	28042	22976	.25					SUB-B
4-28-47-20W4M	HC-F	115.6	115.7	CORE	10.3	20.5	16.7	22.7	33.3	41.6	44.0	58.4	22767	23828	.59					SUB-B
4-28-47-20W4M	HC-F	115.7	116.0	CORE	7.1	13.5		77.6	12.3		10.1				.41					INSF
4-28-47-20W4M	HC-F	116.0	116.3	CORE	11.6	21.4	20.7	23.3	34.9	44.0	41.8	56.0	22383	22181	.71					SUB-B
4-28-47-20W4M	HC-F	116.3	116.6	CORE	12.8	21.6	19.9	12.5	41.5	46.8	46.0	53.2	25474	22872	.47					SUB-B
4-28-47-20W4M	HC-F	116.6	116.9	CORE	12.9	21.4	20.6	7.6	44.4	47.7	48.0	52.3	26633	22618	.41					SUB-B
4-28-47-20W4M	HC-F	116.9	117.2	CORE	4.9	8.0	7.7	67.3	14.9		17.8		8239		.25					INSF
4-28-47-20W4M	HC-F	117.2	117.5	CORE	10.3	15.7	15.9	34.1	27.5		38.4		18901		.21					INSF
4-28-47-20W4M	HC-F	119.0	119.2	CORE	8.4	19.0	14.0	69.9	21.3		8.8		6852		.16					INSF
4-28-47-20W4M	HC-F	119.2	119.5	CORE	13.1	20.2	18.4	16.6	39.9	46.8	43.6	53.2	25328	24207	.74					SUB-B
4-28-47-20W4M	HC-F	119.5	119.8	CORE	14.5	20.0	20.7	33.0	34.5		32.6		20101		.46					INSF
4-28-47-20W4M	HC-F	119.8	120.1	CORE	13.2	21.0	18.7	18.0	39.4	47.1	42.6	52.9	24879	24028	.18					SUB-B

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-28-47-20W4M	HC-F	120.1	120.8	CORE	12.5	17.3	16.9	29.8	31.4		38.8		21062		.24					INSF
4-28-47-20W4M	HC-F	120.8	121.0	CORE	4.8	14.9		93.0	7.0						.07					INSF
16-16-47-21W4M	HC-F	117.3	118.9	CUTT	6.8		18.1	44.5	33.0		22.4		14775		.65					INSF
16-16-47-21W4M	HC-F	166.1	166.1	CUTT	8.6		18.5	21.2	34.4	42.3	44.4	57.7	22804	22846	.70					SUB-B
16-16-48-19W4M	HC-F	42.6	42.6	CUTT	10.7		20.5	28.9	42.8		28.2		19822		.73					INSF
16-16-48-19W4M	HC-F	53.3	53.3	CUTT	8.5		20.5	25.0	35.5	45.8	39.5	54.2	20953	21201	.55					SUB-C
16-16-48-19W4M	HC-F	60.9	60.9	CUTT	7.0		20.4	49.6	28.5		21.9		13026		.69					INSF
16-16-48-19W4M	HC-F	77.7	82.3	CUTT	10.9		20.8	29.4	42.1		28.5		20094		.70					INSF
4-27-48-20W4M	HC-F	62.5	62.5	CUTT	9.8		21.1	36.1	33.2		30.7		17787		.33					INSF
4-27-48-20W4M	HC-F	114.3	114.3	CUTT	8.3		21.2	30.1	33.9		36.0		20036		.53					INSF
4-27-48-21W4M	HC-F	163.1	163.1	CUTT	10.7		17.2	33.2	31.1		35.8		19248		.26					INSF
13-14-49-20W4M	HC-F	103.6	106.7	CUTT	8.7		18.7	40.1	32.0		27.9		15849		1.81					INSF
16-21-49-21W4M	HC-F	109.7	112.8	CUTT	10.3		21.9	18.2	39.5	47.2	42.3	52.8	22967	21190	.65					SUB-C
16-21-49-21W4M	HC-F	111.2	112.8	CUTT			24.5	14.9	38.2	44.1	46.9	55.9	24167	20767	.30					SUB-C
16-21-49-21W4M	HC-F	125.0	125.0	CUTT	11.3		18.7	31.8	33.8		34.4		19517		.73					INSF
16-21-49-21W4M	HC-F	147.8	150.9	CUTT	11.1		20.4	32.5	33.5		34.0		18573		.44					INSF
1-28-49-22W4M	HC-F	167.6	169.2	CUTT	9.8		20.6	11.6	36.0	39.9	52.5	60.1	25572	22544	.90					SUB-B
1-28-49-22W4M	HC-F	185.9	187.5	CUTT	10.6		20.1	14.9	33.7	38.5	51.4	61.5	24965	22904	.89					SUB-B
1-28-49-22W4M	HC-F	193.5	195.1	CUTT	12.4		19.1	24.7	32.7	41.7	42.7	58.3	22727	23441	.85					SUB-B
4-18-50-20W4M	HC-F	128.0	128.0	CUTT	11.1		20.4	46.4	33.8		19.8		13705		.31					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-50-22W4M	HC-F	126.8	127.1	CORE	1.4	19.1		85.1	14.9						.27					INSF
16-21-50-22W4M	HC-F	127.1	127.4	CORE	13.5	26.6	22.1	18.8	31.7	37.9	49.5	62.1	24267	22453	.30					SUB-B
16-21-50-22W4M	HC-F	127.8	128.1	CORE	6.7	23.2		90.8	6.5		2.7				.12					INSF
16-21-50-22W4M	HC-F	128.1	128.3	CORE	13.8	33.5	21.4	18.5	35.5	42.4	46.1	57.6	23979	22355	.34					SUB-B
16-21-50-22W4M	HC-F	135.4	135.6	CORE	8.7	26.4		87.5	12.6						.33					INSF
16-21-50-22W4M	HC-F	135.6	135.9	CORE	13.8	27.0	20.4	26.9	37.5		35.6		21978		.42					INSF
16-21-50-22W4M	HC-F	135.9	136.2	CORE	16.3	32.5	22.9	4.7	40.8	42.5	54.5	57.5	28849	23155	.44					SUB-B
16-21-50-22W4M	HC-F	136.2	136.4	CORE	14.9	31.3	21.9	8.3	38.6	41.5	53.2	58.5	27672	23234	.56					SUB-B
16-21-50-22W4M	HC-F	159.2	160.8	CORE	7.4	20.3		93.5	5.7		.8									INSF
16-21-50-22W4M	HC-F	160.9	161.2	CORE	18.1	27.4	20.5	13.7	39.6	45.3	46.6	54.8	27016	24349	.09					SUB-B
16-21-50-22W4M	HC-F	161.1	161.4	CORE	18.6	27.3	21.8	10.7	38.3	42.3	51.1	57.7	27242	23407	.22					SUB-B
16-21-50-22W4M	HC-F	161.4	161.7	CORE	19.0	30.3	21.3	11.1	37.9	42.0	51.0	58.0	27638	24014	.30					SUB-B
16-21-50-22W4M	HC-F	161.7	162.1	CORE	15.5	24.6	18.2	40.3	24.7		35.1		19166		.12					INSF
16-21-50-22W4M	HC-F	162.6	162.9	CORE	18.8	29.5	22.1	26.6	31.7		41.7		23297		.17					INSF
16-21-50-22W4M	HC-F	162.9	163.2	CORE	19.5	30.4	21.7	7.2	38.2	40.8	54.6	59.2	28659	23893	.30					SUB-B
16-21-50-22W4M	HC-F	163.1	164.6	CUTT	11.3		20.7	28.2	33.1		38.7		20564		.39					INSF
16-21-50-22W4M	HC-F	163.2	163.5	CORE	18.0	27.7	20.8	24.0	33.6	42.7	42.4	57.3	24904	24821	.37					SUB-A
16-21-50-22W4M	HC-F	163.5	163.7	CORE	11.2	24.9	14.8	72.1	15.1		12.9		7204		.19					INSF
4-27-50-23W4M	HC-F	153.9	153.9	CUTT	10.1		19.7	27.5	35.6		36.9		21234		.58					INSF
1-22-51-21W4M	HC-F	77.7	79.2	CUTT	9.9		20.5	33.1	37.0		29.9		19027		1.57					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-28-51-22W4M	HC-F	85.3	89.9	CUTT	12.1		18.8	35.5	37.4		27.1		18408		.85					INSF
1-28-51-22W4M	HC-F	126.5	126.5	CUTT	9.0		19.4	22.4	35.6	44.4	42.0	55.6	22237	22262	1.07					SUB-B
16- 9-51-23W4M	HC-F	106.7	108.2	CUTT	12.5		20.5	22.6	36.1	45.2	41.3	54.8	22672	22355	.96					SUB-B
16- 9-51-23W4M	HC-F	114.3	115.8	CUTT	11.9		19.6	17.2	36.8	43.4	46.0	56.6	24537	23204	.83					SUB-B
16- 9-51-23W4M	HC-F	121.9	121.9	CUTT	12.4		21.6	9.7	38.5	42.1	51.7	57.9	26354	22518	.65					SUB-B
16- 9-51-23W4M	HC-F	152.4	153.9	CUTT	12.3		20.3	12.3	36.3	40.6	51.4	59.5	26223	23381	.79					SUB-B
16-16-52-21W4M	HC-F	44.2	44.2	CUTT	9.7			25.9	43.4		30.7		20597		.76					INSF
16-16-52-21W4M	HC-F	71.6	71.6	CUTT	7.3			39.5	34.5		25.9		16736		1.26					INSF
16-16-52-21W4M	HC-F	71.6	71.6	CUTT	9.7		20.0	17.5	38.3	45.3	44.2	54.7	23281	21939	1.11					SUB-C
8-22-52-22W4M	HC-F	56.4	56.4	CUTT	12.4		21.3	25.3	30.8		43.9		21092		.61					INSF
8-22-52-22W4M	HC-F	89.9	94.5	CUTT	11.2		20.4	28.7	35.3		36.0		21155		.86					INSF
13-16-52-23W4M	HC-F	80.7	80.7	CUTT	9.9		20.2	33.3	29.8		36.9		18610		.62					INSF
1-28-53-23W4M	HC-F	27.4	27.4	CORE			21.8								.91					INSF
4-28-54-25W4M	HC-F	45.7	45.7	CUTT	10.3		22.6	21.2	35.1	43.1	43.7	56.9	22274	20939	.90					SUB-C
4-28-54-25W4M	HC-F	70.2	70.4	CORE	3.8	20.8		91.2	8.5		.2				.17					INSF
4-28-54-25W4M	HC-F	70.4	70.7	CORE	7.7	22.7	19.1	18.0	38.9	46.4	43.2	53.6	24260	23281	.36					SUB-B
4-28-54-25W4M	HC-F	70.4	70.7	CORE			22.3	19.7	36.0	43.7	44.3	56.3	23609	21976	.30					SUB-C
4-28-54-25W4M	HC-F	70.7	71.0	CORE	9.4	24.6	20.8	27.2	37.5		35.3		21562		.31					INSF
4-28-54-25W4M	HC-F	71.0	71.3	CORE	9.2	20.2	19.2	12.0	38.6	43.2	49.4	56.8	26447	23879	.36					SUB-B
4-28-54-25W4M	HC-F	71.3	71.4	CORE	6.8	23.4	16.7	28.3	31.4		40.3		21074		.29					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-28-51-22W4M	HC-F	85.3	89.9	CUTT	12.1		18.8	35.5	37.4		27.1		18408		.85					INSF
1-28-51-22W4M	HC-F	126.5	126.5	CUTT	9.0		19.4	22.4	35.6	44.4	42.0	55.6	22237	22262	1.07					SUB-B
16- 9-51-23W4M	HC-F	106.7	108.2	CUTT	12.5		20.5	22.6	36.1	45.2	41.3	54.8	22672	22355	.96					SUB-B
16- 9-51-23W4M	HC-F	114.3	115.8	CUTT	11.9		19.6	17.2	36.8	43.4	46.0	56.6	24537	23204	.83					SUB-B
16- 9-51-23W4M	HC-F	121.9	121.9	CUTT	12.4		21.6	9.7	38.5	42.1	51.7	57.9	26354	22518	.65					SUB-B
16- 9-51-23W4M	HC-F	152.4	153.9	CUTT	12.3		20.3	12.3	36.3	40.6	51.4	59.5	26223	23381	.79					SUB-B
16-16-52-21W4M	HC-F	44.2	44.2	CUTT	9.7			25.9	43.4		30.7		20597		.76					INSF
16-16-52-21W4M	HC-F	71.6	71.6	CUTT	7.3			39.5	34.5		25.9		16736		1.26					INSF
16-16-52-21W4M	HC-F	71.6	71.6	CUTT	9.7		20.0	17.5	38.3	45.3	44.2	54.7	23281	21939	1.11					SUB-C
8-22-52-22W4M	HC-F	56.4	56.4	CUTT	12.4		21.3	25.3	30.8		43.9		21092		.61					INSF
8-22-52-22W4M	HC-F	89.9	94.5	CUTT	11.2		20.4	28.7	35.3		36.0		21155		.86					INSF
13-16-52-23W4M	HC-F	80.7	80.7	CUTT	9.9		20.2	33.3	29.8		36.9		18610		.62					INSF
1-28-53-23W4M	HC-F	27.4	27.4	CORE			21.8								.91					INSF
4-28-54-25W4M	HC-F	45.7	45.7	CUTT	10.3		22.6	21.2	35.1	43.1	43.7	56.9	22274	20939	.90					SUB-C
4-28-54-25W4M	HC-F	70.2	70.4	CORE	3.8	20.8		91.2	8.5		.2				.17					INSF
4-28-54-25W4M	HC-F	70.4	70.7	CORE	7.7	22.7	19.1	18.0	38.9	46.4	43.2	53.6	24260	23281	.36					SUB-B
4-28-54-25W4M	HC-F	70.4	70.7	CORE			22.3	19.7	36.0	43.7	44.3	56.3	23609	21976	.30					SUB-C
4-28-54-25W4M	HC-F	70.7	71.0	CORE	9.4	24.6	20.8	27.2	37.5		35.3		21562		.31					INSF
4-28-54-25W4M	HC-F	71.0	71.3	CORE	9.2	20.2	19.2	12.0	38.6	43.2	49.4	56.8	26447	23879	.36					SUB-B
4-28-54-25W4M	HC-F	71.3	71.4	CORE	6.8	23.4	16.7	28.3	31.4		40.3		21074		.29					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-28-54-25W4M	HC-F	71.4	71.6	CORE	3.8	18.7	10.9	81.0	12.9		6.2				.14					INSF
4-28-54-25W4M	HC-F	73.1	73.1	CUTT	10.8		18.9	26.1	33.9		40.0		20839		.71					INSF
4-28-54-25W4M	HC-F	80.2	80.3	CORE	4.1	16.4		90.7	7.3		2.1				.22					INSF
4-28-54-25W4M	HC-F	80.3	80.7	CORE	6.8	17.9	16.5	42.2	28.1		29.7		16794		.36					INSF
4-28-54-25W4M	HC-F	81.4	81.7	CORE	8.6	17.3	17.5	17.7	39.5	47.0	42.8	53.0	24958	24446	.43					SUB-A
4-28-54-25W4M	HC-F	81.7	82.0	CORE	7.7	21.0	19.1	14.5	39.2	45.1	46.3	54.9	25381	23514	.30					SUB-B
4-28-54-25W4M	HC-F	81.7	82.0	CORE				17.2							.30	62.80	3.80			INSF
4-28-54-25W4M	HC-F	82.0	82.1	CORE	7.8	20.9	17.6	19.0	35.9	43.3	45.1	56.8	23283	23093	.21					SUB-B
4-28-54-25W4M	HC-F	82.1	82.3	CORE	3.9	5.7		89.2	9.8		1.0				.19					INSF
4-28-54-25W4M	HC-F	138.7	140.2	CUTT	11.1		18.5	26.3	32.7		40.9		20618		.97					INSF
16- 8-54-27W4M	WP-F	185.2	185.8	CUTT	5.8			18.0	35.0		47.0		23167		.39					INSF
9-20-55-26W4M	HC-F	59.4	60.9	CUTT			24.7	11.9	40.7	45.6	47.4	54.4	25191	20897	.30					SUB-C
9-20-55-26W4M	HC-F	59.4	60.9	CUTT	8.3		19.6	20.3	33.5	40.6	46.1	59.4	22116	21597	1.30					SUB-C
16-21-55-27W4M	WP-F	63.4	64.1	CUTT	6.7			16.0	38.2		45.8		23632		.33					INSF
9-20-56-27W4M	WP-F	111.2	113.2	CUTT	6.4			9.1	38.4		52.5		25572		.29					INSF
9-16-59-22W4M	WP-F	137.0	137.8	CUTT	6.3			12.3	38.1		49.6		24430		.54					INSF
1-27-59-23W4M	WP-F	180.4	182.0	CUTT	7.2			11.0	38.8		50.2		24979		.23					INSF
2-21-60-25W4M	WP-F	90.5	91.4	CUTT	6.7			8.9	39.4		51.7		26000		.34					INSF
2-21-60-25W4M	WP-F	204.4	205.3	CUTT	6.4			13.5	37.1		49.4		24665		.34					INSF
16-21-61-22W4M	WP-F	47.2	48.0	CUTT	6.2			12.4	40.1		47.5		23897		.32					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-21-61-24W4M	WP-F	154.5	155.1	CUTT	6.6			16.0	37.3		46.7		23246		.51					INSF
9-17-61-26W4M	WP-F	217.0	217.6	CUTT	6.4			10.0	38.8		51.2		24851		.50					INSF
1-16-62-21W4M	WP-F	24.0	24.8	CUTT	7.3			8.8	40.5		50.7		24853		.39					INSF
13-11-43-	1W5M	SC-M	265.2	267.3	CUTT										.77					INSF
13-21-45-	1W5M	SC-M	212.8	213.1	CORE	6.5	18.1	12.8	62.9	16.0		21.1		9918	.16					INSF
13-21-45-	1W5M	SC-M	213.1	213.4	CORE		17.3	12.6	43.7	22.6		33.7		16142	.26					INSF
13-21-45-	1W5M	SC-M	213.1	213.4	CORE			14.8	41.0	22.9		36.1		17422	.30	44.90	2.70			INSF
13-21-45-	1W5M	SC-M	213.4	213.7	CORE	7.9	17.3	13.2	35.2	24.7		40.1		19462	.28					INSF
13-21-45-	1W5M	SC-M	213.7	214.0	CORE	7.7	24.6		81.6											INSF
13-21-45-	1W5M	SC-M	214.0	214.3	CORE	7.5	15.7	15.3	27.2	26.1		46.7		22078	.27					INSF
13-21-45-	1W5M	SC-M	214.3	214.6	CORE	4.8	12.6	11.4	68.0	15.7		16.3		8460	.15					INSF
13-21-45-	1W5M	SC-M	214.6	214.9	CORE	7.5	15.2	13.1	33.3	29.8		36.9		19671	.38					INSF
13-21-45-	1W5M	SC-M	214.9	215.2	CORE	8.0	19.6	13.6	44.8	25.9		29.3		16242	.38					INSF
13-21-45-	1W5M	SC-M	215.2	215.5	CORE	7.9	20.0	12.9	17.5	30.6	36.0	51.9	64.0	25298	26379	.26				SUB-A
13-21-45-	1W5M	SC-M	215.5	215.8	CORE	7.5	16.7	13.5	18.8	33.7	40.3	47.5	59.7	24586	25807	.37	61.32	4.19	.94	14.36 SUB-A
13-21-45-	1W5M	SC-M	215.8	216.1	CORE	8.4	21.0	15.0	44.6	23.5		31.9		15610		.20				INSF
13-21-45-	1W5M	SC-M	216.1	216.4	CORE	9.2	23.7	16.7	66.0	15.8		18.2		8443		.23				INSF
13-21-45-	1W5M	SC-M	216.4	216.6	CORE	7.1	15.8	14.0	22.8	29.8	37.0	47.4	63.0	23541	25695	.52				SUB-A
13-21-45-	1W5M	SC-M	216.6	216.7	CORE	7.6	25.7		85.2											INSF
13-21-45-	1W5M	SC-M	216.7	217.0	CORE	8.1	16.8	14.9	8.7	34.1	36.8	57.2	63.2	27689	25614	.23				SUB-A

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-21-45-	1WSM	SC-M	217.0	217.3	CORE	8.3	16.5	14.2	9.5	36.3	39.6	54.2	60.4	27435	25814	.17					SUB-A
13-21-45-	1WSM	SC-M	217.3	217.6	CORE	3.0	14.3		91.0												INSF
13-21-45-	1WSM	SC-M	250.0	250.3	CORE	3.2	8.9		92.7												INSF
13-21-45-	1WSM	SC-M	250.3	250.6	CORE	5.4	15.5		82.8												INSF
13-21-45-	1WSM	SC-M	250.6	250.9	CORE	8.4	17.1	14.2	37.2	23.6		39.2		18338		.31					INSF
13-21-45-	1WSM	SC-M	250.9	251.2	CORE	7.5	17.4	14.4	10.6	37.2	41.0	52.2	59.0	27130	25751	.31	68.67	3.91	.96	15.58	SUB-A
13-21-45-	1WSM	SC-M	251.2	251.5	CORE	6.3	15.7	12.0	45.4	22.5		32.1		16045		.34					INSF
13-21-45-	1WSM	SC-M	251.5	251.8	CORE	6.7	18.1	12.0	45.8	22.9		31.3		15531		.36					INSF
13-21-45-	1WSM	SC-M	251.8	252.1	CORE	7.6	14.2	13.6	8.9	37.1	40.2	54.0	59.8	27812	26209	.35					SUB-A
13-21-45-	1WSM	SC-M	252.1	252.2	CORE	6.7	14.0	12.7	45.8	23.2		31.0		15710		.28					INSF
13-21-45-	1WSM	SC-M	252.2	252.4	CORE	3.0	13.6		92.1												INSF
4-22-46-	1WSM	SC-M	175.3	176.8	CUTT	5.9			11.7	35.0		53.3		26747		.41					INSF
8-28-47-	1WSM	SC-M	121.9	123.4	CUTT	7.4		16.9	7.7	34.5	36.9	57.8	63.1	27584	24623	.24					SUB-A
8-28-47-	1WSM	SC-M	121.9	123.4	CUTT			17.7	8.2	32.1	34.5	59.7	65.5	27168	24116	.20	68.60	4.00			SUB-B
15-22-47-	2WSM	SC-M	164.6	170.7	CUTT	5.5		14.4	7.4	34.3	36.6	58.3	63.4	28638	26323	.43					SUB-A
15-22-47-	2WSM	SC-M	185.9	187.5	CUTT	5.2		12.5	17.2	32.3	37.9	50.5	62.1	25381	26530	.39					SUB-A
15-22-47-	2WSM	SC-M	202.7	204.2	CUTT	5.4		12.9	16.1	31.0	35.8	52.9	64.2	25865	26565	.63					SUB-A
15-22-47-	2WSM	SC-M	214.9	216.4	CUTT	5.2		13.1	18.6	31.0	36.8	50.4	63.2	25009	26342	.50					SUB-A
4-27-47-	3WSM	SC-M	224.0	225.6	CUTT	4.8			18.6	31.8		49.6		25260		.40					INSF
4-27-47-	3WSM	SC-M	234.7	236.2	CUTT	5.0		14.2	12.5	33.3	37.3	54.2	62.7	27226	26426	.35					SUB-A

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-27-47- 3W5M	SC-M	265.2	266.7	CUTT	4.2		12.4	22.1	30.4	37.5	47.5	62.5	24616	27275	.42					HVB-C
4-21-48- 2W5M	SC-M	100.6	102.1	CUTT	5.3		13.3	15.0	34.4	39.6	50.6	60.4	24907	25125	.31					SUB-A
-21-48- 3W5M	SC-M	158.8	159.1	CORE	6.4	17.0	11.9	11.7	34.7	38.6	53.6	61.4	26649	26421	.26					SUB-A
14-21-48- 3W5M	SC-M	157.3	157.6	CORE	6.5	20.8	14.1	38.3	28.0		33.7		18299		.26					INSF
14-21-48- 3W5M	SC-M	157.6	157.9	CORE	4.7	14.1	10.7	53.8	25.9		20.3		12865		.19					INSF
14-21-48- 3W5M	SC-M	157.9	158.2	CORE	6.3	17.0	13.2	15.6	30.6	35.2	53.8	64.8	25391	25821	.31					SUB-A
14-21-48- 3W5M	SC-M	157.9	158.2	CORE			14.5	16.1	31.1	36.0	52.8	64.0	25516	25630	.30	65.30	3.70			SUB-A
14-21-48- 3W5M	SC-M	158.2	158.5	CORE	6.8	18.5	14.4	11.2	31.2	34.4	57.6	65.6	27007	25791	.23	69.89	2.84	1.00	14.94	SUB-A
14-21-48- 3W5M	SC-M	158.5	158.8	CORE	6.7	18.3	15.5	10.9	52.0	58.0	37.1	42.1	26709	25067	.24					SUB-A
14-21-48- 3W5M	SC-M	159.1	159.4	CORE	2.2	11.7		95.6												INSF
14-21-48- 3W5M	SC-M	187.1	187.5	CORE	6.3	17.3		92.4												INSF
14-21-48- 3W5M	SC-M	187.5	187.8	CORE	6.5	20.7	14.0	41.3	21.8		36.9		17178		.31					INSF
14-21-48- 3W5M	SC-M	187.8	188.1	CORE	6.7	19.7	14.3	11.2	30.7	33.8	58.1	66.2	27093	25909	.33					SUB-A
14-21-48- 3W5M	SC-M	188.1	188.4	CORE	5.8	14.9	11.8	35.2	24.3		40.5		18836		.23					INSF
14-21-48- 3W5M	SC-M	188.4	188.7	CORE	6.9	18.5	14.9	16.0	29.5	34.1	54.5	65.9	25426	25370	.25					SUB-A
14-21-48- 3W5M	SC-M	188.7	189.0	CORE	6.1	20.1	17.1	6.3	32.7	34.5	61.0	65.5	28705	25221	.21					SUB-A
14-21-48- 3W5M	SC-M	189.0	189.3	CORE	6.2	19.3	15.6	5.2	34.8	36.4	60.0	63.6	29196	25867	.20	72.85	4.44	1.11	16.23	SUB-A
14-21-48- 3W5M	SC-M	189.3	189.6	CORE	6.6	20.2	15.3	7.7	33.7	36.0	58.6	64.0	28252	25746	.30					SUB-A
14-21-48- 3W5M	SC-M	189.6	189.7	CORE	6.2	19.8	13.6	27.6	27.5		44.9		22085		.33					INSF
14-21-48- 3W5M	SC-M	189.7	189.9	CORE	2.6	9.2		93.6												INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
9-17-48- 4W5M	SC-M	185.9	189.0	CUTT	4.4			48.3	20.9		30.8		15491		.24					INSF
9-17-48- 4W5M	SC-M	230.1	233.2	CUTT	5.5		13.0	10.1	32.8	35.9	57.1	64.1	27447	26388	.29					SUB-A
9-21-48- 5W5M	SC-M	197.5	199.6	CUTT	5.3		11.9	38.8	29.3		31.9		18378		.46					INSF
16-21-49- 4W5M	SC-M	155.4	160.0	CUTT	6.8		15.8	14.8	34.2	39.2	51.0	60.8	25305	24625	.33					SUB-A
14-27-49- 7W5M	SC-M	265.2	272.8	CUTT	5.7			26.4	29.1		44.5		22113		.38					INSF
9-30-50- 5W5M	SC-M	117.3	123.4	CUTT	7.4			12.2	36.8		51.0		25574		.17					INSF
9-30-50- 5W5M	SC-M	134.1	135.6	CUTT	6.1			28.1	31.0		40.9		21643		.68					INSF
9-21-50- 7W5M	SC-M	234.7	243.9	CUTT	6.7		14.2	11.7	34.3	38.2	54.0	61.8	26084	25102	.21					SUB-A
12-20-51- 5W5M	SC-M	105.1	120.4	CUTT	7.0		15.1	16.5	33.6	39.2	49.9	60.8	24116	24125	.25					SUB-B
16-23-51- 8W5M	SC-M	233.2	234.7	CUTT	5.5		14.4	25.7	29.6		44.7		21692		.26					INSF
16- 9-52- 6W5M	SC-M	134.1	140.2	CUTT	5.6		13.9	43.0	27.2		29.8		15545		.36					INSF
16- 9-52- 6W5M	SC-M	134.1	140.2	CUTT			15.2	23.2	30.7	38.4	46.1	61.6	22399	24125	.50	57.50	3.50			SUB-B
16- 8-53- 8W5M	SC-M	163.4	163.7	CORE	6.6	16.8	13.8	19.4	33.6	40.4	47.0	59.6	24825	26135	.70					SUB-A
16- 8-53- 8W5M	SC-M	163.4	163.7	CORE	4.6	12.1	10.1	77.0	12.8		10.2		4619		.27					INSF
16- 8-53- 8W5M	SC-M	163.7	164.0	CORE	4.0	12.3		81.6												INSF
16- 8-53- 8W5M	SC-M	164.0	164.3	CORE	6.2	16.3	13.9	34.1	37.5		28.4		19157		.43					INSF
16- 8-53- 8W5M	SC-M	164.3	164.6	CORE	7.0	18.7	15.1	15.3	35.4	40.9	49.3	59.1	25000	24693	.35					SUB-A
16- 8-53- 8W5M	SC-M	164.6	164.9	CORE	6.2	16.1	14.2	30.6	28.6		40.8		19876		.26					INSF
16- 8-53- 8W5M	SC-M	164.9	165.2	CORE	6.2	16.2	13.7	29.7	30.6		39.7		19813		.26					INSF
16- 8-53- 8W5M	SC-M	165.2	165.5	CORE	7.3	19.6	15.0	10.9	30.4	33.4	58.7	66.6	26714	25235	.21	70.00	3.89	.90	14.14	SUB-A

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16- 8-53- 8W5M	SC-M	165.5	165.8	CORE	6.3	16.4	11.7	19.0	34.7	41.7	46.3	58.3	22748	24530	.19					SUB-A
16- 8-53- 8W5M	SC-M	165.8	166.1	CORE	5.9	17.6	13.8	31.6	45.4		23.0		19417		.18					INSF
16- 8-53- 8W5M	SC-M	166.1	166.4	CORE	7.1	19.1	14.3	11.2	35.3	38.1	53.5	60.9	26021	24879	.20					SUB-A
16- 8-53- 8W5M	SC-M	166.4	166.7	CORE	6.2	18.8	14.9	22.7	31.6	39.4	45.7	60.6	23255	25009	.22					SUB-A
16- 8-53- 8W5M	SC-M	166.7	167.0	CORE	2.6	17.6		87.2												INSF
16- 8-53- 8W5M	SC-M	167.0	167.3	CORE	2.1	16.0		95.0												INSF
16-20-54- 2W5M	WP-F	48.7	49.8	CUTT	5.4			11.6	38.5		49.9		24693		.26					INSF
16-20-54- 2W5M	WP-F	171.9	173.3	CUTT	5.8			9.2	39.2		51.6		25407		.30					INSF
13-21-54- 8W5M	SC-M	179.8	185.9	CUTT	5.2			22.5					23572		.78					INSF
13-24-55- 2W5M	WP-F	180.0	181.0	CUTT	6.7			12.1	37.1		50.8		24914		.43					INSF
13-22-55- 9W5M	SC-M	100.6	101.2	CUTT	6.4		16.8	9.2	35.9	39.0	54.9	61.0	27461	24909	.34					SUB-A
13-22-55- 9W5M	SC-M	109.7	112.8	CUTT	5.3		14.1	16.7	32.5	37.8	50.8	62.2	25214	25653	1.08					SUB-A
13-15-55-12W5M	UNKN	199.0	199.0	CUTT	5.3			30.6	28.5		40.9		21734		.30					INSF
4-26-56- 2W5M	WP-F	91.7	92.3	CUTT	5.6			8.8	37.3		53.9		25223		.32					INSF
4-26-56- 2W5M	WP-F	91.7	91.9	CORE	5.4			8.9	43.7		47.4		26091		.40					INSF
4-26-56- 2W5M	WP-F	91.9	92.1	CORE	5.3			10.0	43.4		46.6		25995		.45					INSF
4-26-56- 2W5M	WP-F	92.1	92.3	CORE	3.6			73.3	19.1		7.6		6587		.11					INSF
4-26-56- 2W5M	WP-F	92.3	92.5	CORE	3.5			67.2	17.0		15.8		8411		.21					INSF
4-26-56- 2W5M	WP-F	92.5	92.6	CORE	5.6			13.8	40.4		45.8		24616		.30					INSF
4-26-56- 2W5M	WP-F	92.6	94.2	CUTT	5.8			11.4	39.2		49.4		24539		.27					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-26-56- 2W5M	WP-F	92.6	92.8	CORE	5.6			9.3	41.2		49.5		26184		.24	66.95	4.40	1.39	17.71	INSF
4-26-56- 2W5M	WP-F	92.8	92.9	CORE	5.8			16.9	39.3		43.8		23779		.28					INSF
4-26-56- 2W5M	WP-F	93.0	93.2	CORE	5.3			23.7	37.2		39.1		21869		.30					INSF
4-26-56- 2W5M	WP-F	93.2	93.3	CORE	5.9			24.6	37.1		38.3		21162		.30	54.02	3.74	1.10	16.19	INSF
4-26-56- 2W5M	WP-F	93.3	93.5	CORE	5.7			6.4	41.8		51.8		26942		.28					INSF
4-26-56- 2W5M	WP-F	93.5	93.6	CORE	5.9			10.4	42.4		47.2		25412		.28					INSF
4-26-56- 2W5M	WP-F	93.6	93.8	CORE	6.0			6.5	39.6		53.9		26591		.31					INSF
4-26-56- 2W5M	WP-F	93.7	93.9	CORE	6.5			6.6	41.1		52.3		26837		.19	68.90	4.56	1.50	18.27	INSF
4-26-56- 2W5M	WP-F	93.9	94.1	CORE	5.9	26.4		7.3	43.2		49.5		26668		.37					INSF
4-26-56- 2W5M	WP-F	94.1	94.2	CORE	7.0	25.5		4.7	39.3		56.0		27393		.37					INSF
4-26-56- 2W5M	WP-F	94.2	94.5	CORE	6.7	25.4		4.5	39.8		55.7		27628		.34	65.19	4.40	1.28	24.29	INSF
5-24-56- 3W5M	WP-F	105.3	106.4	CUTT	6.1			11.6	36.4		52.0		23293		.39					INSF
4-26-56-10W5M	SC-M	60.9	62.5	CUTT	4.9			32.7					20150		.96					INSF
16-21-56-11W5M	SC-M	216.6	216.7	CORE	3.2	11.5		86.9												INSF
16-21-56-11W5M	SC-M	216.7	217.0	CORE	8.0	21.3	15.2	39.1	29.1		31.8		17959		.37					INSF
16-21-56-11W5M	SC-M	217.0	217.3	CORE	6.6	23.8	13.3	51.4	20.9		27.7		13426		.29					INSF
16-21-56-11W5M	SC-M	217.3	217.6	CORE	7.3	19.7	14.9	31.0	30.0		39.0		20811		.87					INSF
16-21-56-11W5M	SC-M	217.3	217.6	CORE			16.6	27.8	29.7		42.5		21934		1.00	55.10	3.50			INSF
16-21-56-11W5M	SC-M	217.6	217.9	CORE	3.0	16.7		89.4												INSF
16-21-56-11W5M	SC-M	217.9	218.2	CORE	6.7	16.9	13.4	32.4	27.1		40.5		20292		.59					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	ULT-ANALYSIS (DRY) C	ULT-ANALYSIS (DRY) H	ULT-ANALYSIS (DRY) N	ULT-ANALYSIS (DRY) O	COAL RANK
16-21-56-11W5M	SC-M	218.2	218.5	CORE	5.5	19.0		80.1												INSF
16-21-56-11W5M	SC-M	218.5	218.9	CORE	6.1	13.5	9.4	47.9	21.3		30.8		16226		.28					INSF
16-21-56-11W5M	SC-M	218.9	219.0	CORE	8.7	42.2		91.0												INSF
16-21-56-11W5M	SC-M	219.0	219.2	CORE	7.0	15.6	12.8	27.2	25.7		47.1		21916		.30					INSF
16-21-56-11W5M	SC-M	219.2	219.5	CORE	8.4	19.5	15.6	11.4	32.2	35.6	56.4	64.4	26935	25374	.28					SUB-A
16-21-56-11W5M	SC-M	219.5	219.8	CORE	8.8	19.4	15.7	9.1	40.5	44.1	50.4	55.9	27517	25295	.29	69.99	4.17	1.01	15.42	SUB-A
16-21-56-11W5M	SC-M	219.8	220.1	CORE	8.0	17.0	13.9	14.7	40.7	47.0	44.6	53.1	25800	25735	.28					SUB-A
16-21-56-11W5M	SC-M	220.1	220.4	CORE	3.3	16.3		78.8												INSF
16-21-56-11W5M	SC-M	221.6	221.7	CORE	2.2	11.2		92.1												INSF
16-21-56-11W5M	SC-M	221.7	221.9	CORE	7.5	19.5	17.7	16.1	31.4	36.2	52.5	63.8	25539	24546	1.08					SUB-A
16-21-56-11W5M	SC-M	221.9	222.2	CORE	6.8	19.6	16.2	24.5	28.5	36.0	47.0	64.0	22688	24435	.38					SUB-A
16-21-56-11W5M	SC-M	222.6	222.8	CORE	5.5	17.6	13.3	44.1	23.7		32.2		16615		1.06					INSF
16-21-56-11W5M	SC-M	222.8	223.1	CORE	2.5	11.8		93.5												INSF
16-21-56-11W5M	SC-M	223.4	223.7	CORE	4.6	14.5	11.0	64.8	16.6		18.6		8723		.27					INSF
16-21-56-11W5M	SC-M	223.7	224.0	CORE	6.8	15.3	12.9	30.8	28.0		41.2		20680		.46					INSF
16-21-56-11W5M	SC-M	224.0	224.3	CORE	5.9	16.3	12.8	58.4	21.7		19.9		10497		.21					INSF
16-21-56-11W5M	SC-M	224.3	224.6	CORE	4.4	15.2		80.0												INSF
16-21-56-11W5M	SC-M	224.6	225.0	CORE	6.7	20.5	13.1	43.3	22.4		34.3		16498		.36					INSF
16-21-56-11W5M	SC-M	225.0	225.3	CORE	7.7	17.2	14.7	21.1	29.8	36.3	49.1	63.7	23969	25386	.44					SUB-A
16-21-56-11W5M	SC-M	225.3	225.6	CORE	6.6	19.8	13.4	34.7	33.5		31.8		19499		.33					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-56-11W5M	SC-M	225.6	225.7	CORE	5.9	41.4		92.3												INSF
16-21-56-11W5M	SC-M	225.7	225.9	CORE	4.0	13.2		94.2												INSF
1- 8-56-12W5M	SC-M	257.6	260.6	CUTT	5.7			26.7	29.8		43.5		21955		.25					INSF
1- 8-56-12W5M	SC-M	257.6	260.6	CUTT			16.2	17.6	32.0	37.7	50.4	62.3	24795	24718	.30	63.10	4.00			SUB-A
13-33-56-12W5M	SC-M	178.3	179.8	CUTT	5.3			32.8	26.9		40.3		19266		.26					INSF
13-33-56-12W5M	SC-M	205.7	207.3	CUTT	6.5		13.7	14.2	34.2	39.0	51.6	61.0	26123	25991	.35					SUB-A
13-33-56-12W5M	SC-M	219.5	221.0	CUTT	6.3		13.1	27.4	28.3		44.3		21702		.31					INSF
16-21-57- 3W5M	WP-F	30.7	31.7	CUTT	7.6			8.2	40.9		50.9		24765		.44					INSF
16-21-57- 3W5M	WP-F	32.0	32.7	CUTT	6.7			15.6	39.7		44.7		23055		.95					INSF
13-14-57-11W5M	SC-M	150.9	155.4	CUTT	6.2		15.1	21.4	32.4	39.8	46.2	60.2	23402	24723	.49					SUB-A
13-21-58- 3W5M	WP-F	83.5	84.6	CUTT	6.1			6.5	40.4		53.1		26886		.28					INSF
13-21-58- 3W5M	WP-F	83.5	84.7	CUTT	6.5			9.9	39.3		50.8		25325		.21					INSF
13-21-58- 3W5M	WP-F	84.7	86.4	CUTT	5.3			18.1	39.2		42.7		23127		.31					INSF
13-21-58- 3W5M	WP-F	84.7	86.4	CUTT	5.3			6.2	42.0		51.8		26809		.26					INSF
4-26-58- 5W5M	WP-F	118.9	119.2	CUTT	6.6			9.2	39.3		51.5		26323		.29					INSF
4-26-58- 5W5M	WP-F	119.2	119.8	CUTT	6.2			17.4	37.8		44.8		23809		.35					INSF
4-26-58- 5W5M	WP-F	126.5	128.8	CUTT	6.7			13.8	35.9		50.3		24828		.32					INSF
4-27-58- 6W5M	WP-F	99.5	100.4	CUTT	6.0			12.1	36.8		51.1		25263		.30					INSF
4-27-58- 6W5M	WP-F	147.7	149.5	CUTT	5.8			11.0	38.6		50.1		25872		.35					INSF
16-20-59- 4W5M	WP-F	52.1	53.2	CUTT	5.8			17.4	36.0		46.6		23032		.22					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-20-59- 4W5M	WP-F	53.3	54.1	CUTT	6.0			9.5	38.6		51.9		25828		.36					INSF
8-20-59- 6W5M	WP-F	89.1	90.0	CUTT	6.3			6.7	39.0		54.3		27049		.29					INSF
8- 6-59-12W5M	SC-M	144.8	147.8	CUTT	6.0		15.5	22.6	30.7	38.1	46.7	61.9	23879	25428	.53					SUB-A
1-22-63- 1W5M	WP-F	14.9	15.7	CUTT	7.6			9.5	40.4		50.1		25079		.32					INSF
10-20-67-10W6M	WP-F	194.6	195.4	CUTT	3.5			15.8	33.6		50.6		27277		.39					INSF

B. APPENDIX 2

CONVERSION CHART

given base	required base	conversion
as received	dry	100/(100-MAR)
as received	dry ash free	100/(100-MAR-AAR)
as received	moist	(100-MEQ)/(100-MAR)
dry	as received	(100-MAR)/100
dry	dry ash free	100/(100-AD)
dry	moist	(100-MEQ)/100

Where:

MAR = as received moisture

MEQ = equilibrium moisture

AAR = ash, as received basis

AD = ash, dry basis

Multiply the analysis component to be converted by the conversion factor in order to obtain the required base.

C. APPENDIX 3

PARR FORMULAE

$$DMMFFC = [(FC-0.15S)(100)]/[100-(MEQ+1.08A+0.55S)]$$

$$DMMFVM = 100-DMMFFC$$

$$MMMFCV = [(CV-50S)(100)]/[100-(1.08A+0.55S)]$$

Where:

DMMFFC = dry mineral matter free fixed carbon

DMMFVM = dry mineral matter free volatile matter

MMMFCV = moist mineral matter free calorific value, BTU/lb

FC = fixed carbon, moist basis

S = sulfur, moist basis

MEQ = equilibrium moisture

A = ash, moist basis

CV = calorific value, moist basis, BTU/lb

To convert BTU/lb values to kJ/kg, multiply the BTU/lb value by a conversion factor of 2.326.

D. APPENDIX 4

REMOVED OVERBURDEN DATA

The location given (meridian, township, range) represents the centre of a 9 township block. The removed overburden value represents the average removed overburden for the 9 township block.

Mer	Twp	Rge	Removed overburden (m)
4	5	5	886
4	11	5	995
4	14	14	1090
4	26	17	1363
4	29	17	1342
4	32	17	1236
4	35	17	1193
4	38	17	1167
4	41	17	1245
4	14	20	1588
4	17	20	1614
4	20	20	1659
4	23	20	1470
4	29	20	1344
4	32	20	1251
4	41	20	1242
4	44	20	1190
4	47	20	1249

4	50	20	1092
4	53	20	1284
4	8	23	1908
4	14	23	1678
4	50	23	1163
4	35	26	1550
4	38	26	1567
4	41	26	1658
4	44	26	1643
4	47	26	1638
4	53	26	1308
4	56	26	1197
5	44	2	1508
5	47	2	1527
5	50	8	1479
5	53	8	1557
5	56	8	1524
5	56	11	1414
5	59	11	1477